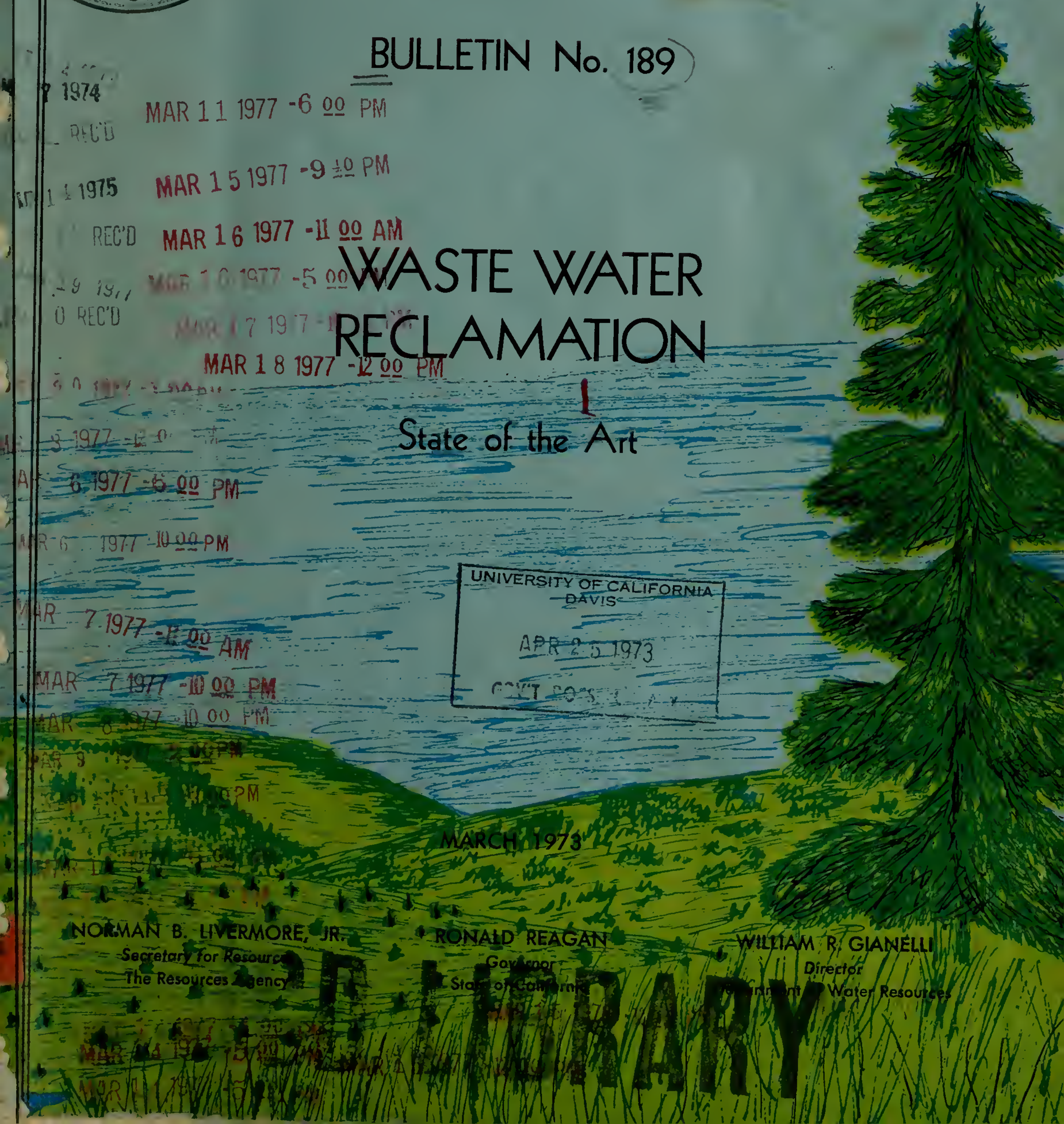
STATE OF CALIFORNIA
(The Resources Agency)

Department of Water Resources

BULLETIN No. 189

WASTE WATER RECLAMATION

State of the Art



MARCH 1973

NORMAN B. LIVERMORE, JR.
Secretary for Resources
The Resources Agency

RONALD REAGAN
Governor
State of California

WILLIAM R. GIANELLI
Director
Department of Water Resources

Copies of this bulletin are available without charge from:
State of California
DEPARTMENT OF WATER RESOURCES
P.O. Box 388
Sacramento, California 95802

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FOREWORD

The conservation of California's water, and the closely related task of environmental preservation, require efficient use of our water resources. Through prevention of wasteful practices during the initial use of water, and careful treatment of waste water as it is used and returned to rivers and streams, we can partially achieve this goal. However, an even more pronounced step towards true environmental protection and water conservation will result from increased reclamation of waste water—the treatment and reuse of our municipal, industrial, and agricultural water supplies.

Increased reclamation of waste water can mean fewer pollutants discharged to receiving waters. Reuse of once-used water will augment needed supplemental supplies and reduce the necessity for further importation of water in some parts of California.

Bulletin No. 189 is the Department of Water Resource's first comprehensive presentation on the State of the Art of waste water reclamation. The bulletin explores the physical, administrative, and technological aspects of the subject; it reports past and present accomplishments, along with a look at the future of waste water reclamation.

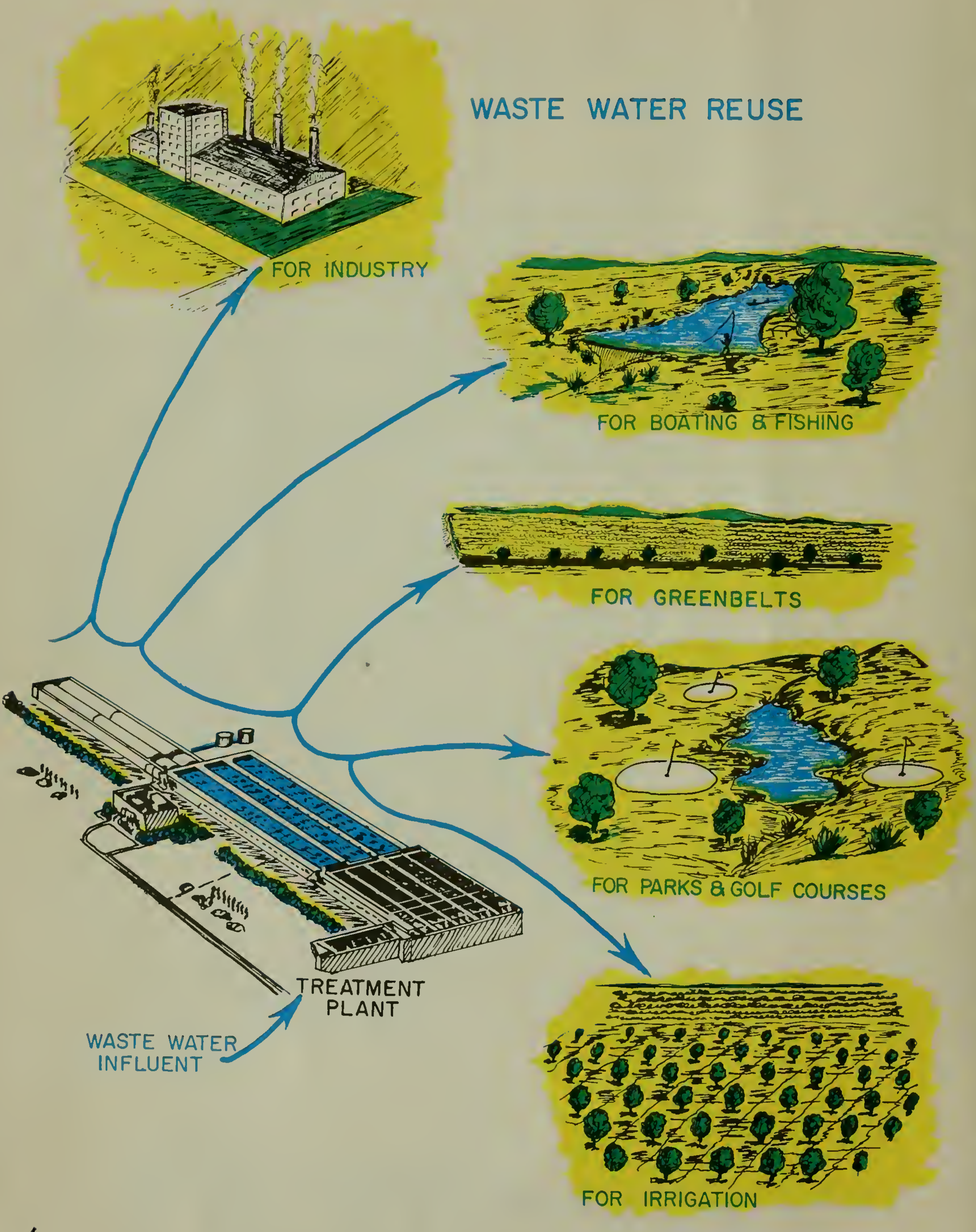
This report is intended for the use of the State Legislature, the California Water Commission, other organizations, and anyone interested in waste water reclamation. However, it is not a detailed technical paper for the professional engineer.

The Department of Water Resources is directed to pursue waste water reclamation activities by Section 230 of the California Water Code. Since 1957, the Department has published a series of periodic reports on current waste water production and reclamation practices, as well as two other series of reports on areal overview and feasibility studies of reclamation potential.

As the State of the Art advances, these Department reports will document our progress in achieving fuller environmental enhancement and efficient use of our water resources through reclamation and reuse.

W R Gianelli

William R. Gianelli, Director
Department of Water Resources
The Resources Agency
March 1, 1973


WASTE WATER REUSE
FOR INDUSTRY
FOR BOATING & FISHING
FOR GREENBELTS
FOR PARKS & GOLF COURSES
FOR IRRIGATION
TREATMENT PLANT
WASTE WATER INFLUENT

I. INTRODUCTION

In this day of special concern for the environment, the reclamation of waste water merits special attention. Moreover, with today's ever-increasing water demands, any plan for the efficient management of resources must include reuse of available water supplies.

The term "waste water" includes:

1. Municipal wastes, i.e.,
   a. Domestic sewage, liquid or solid, carried by a community sewerage system.
   b. Industrial wastes resulting from any production, manufacturing, or processing operation, that are discharged to a municipal sewerage system.
2. Industrial wastes that are discharged directly to rivers, lakes, estuaries, or the ocean.
3. Agricultural return water that has been so degraded that it is no longer usable for irrigation.

Why Reclaim Waste Water?

The reclamation of waste water serves several important purposes. Waste water reclamation may:

1. Provide pollution control and thus greater protection for the environment.
2. Augment natural water supplies, thus reducing the need for development of new sources and imports of water, and permitting rivers to remain in their natural state.
3. Provide a more economical alternative source of water for many uses.

Increased Control of Pollution

Increased waste water treatment will mean fewer contaminants discharged to receiving waters. Because of increasing waste flows, and particularly the increased discharge of chemicals and toxic metals, the practice of discharging conventionally treated wastes into rivers and streams is becoming increasingly hazardous—not only to people who use these streams but also to fish and other aquatic life. However, the benefits to be derived from the reclamation of waste water should encourage waste producers to reduce these discharges at their source.

For many years, waste dischargers have traditionally provided nominal treatment—or none at all—and then have relied on receiving streams to purify discharged effluents by natural dilution and assimilation. Recently, however, a powerful public clamor against pollution, together with the possible economic gain offered by waste water reclamation, has brought about a new philosophy—which demands that waste water receive the most practicable available treatment with minimum dependence on natural purification processes.

Only a few years ago, many communities discharged their wastes to streams and rivers without great regard for the consequences. Bacteria * and other microorganisms converted the sewage or other organic matter into new bacterial cells, carbon dioxide, and other products. However, bacteria cannot perform this chore without oxygen—oxygen the stream acquires from the air and from plants that grow in the water itself. The dissolved oxygen in the stream is also essential to fish and other aquatic organisms; without it, they cannot survive.

If only nominal amounts of sewage are discharged to a stream, the oxygen used to neutralize it is quickly restored, and aquatic life is not significantly affected. However, when sewage loads become excessive, taking more dissolved oxygen from the water than can readily be restored, the sewage will decay and the water will soon begin to give off unpleasant odors. Unless the waste loads are reduced, the stream will eventually lose all of its oxygen, and the water will literally "die."

As today's populations continue to grow and the amount of wastes continues to increase, the discharge of pollutants will continue to increase the burden on our rivers and streams. Moreover, many of today's pollutants—phosphates, pesticides, synthetic chemicals, to name only a few—are not as readily separated from waste water as are bacteria, suspended matter, and degradable organics.

The challenge, then, is to meet the problem through better and more efficient methods for (1) removing pollutants from waste water before it is discharged, and (2) preventing noxious or toxic wastes from entering natural waters through source control.

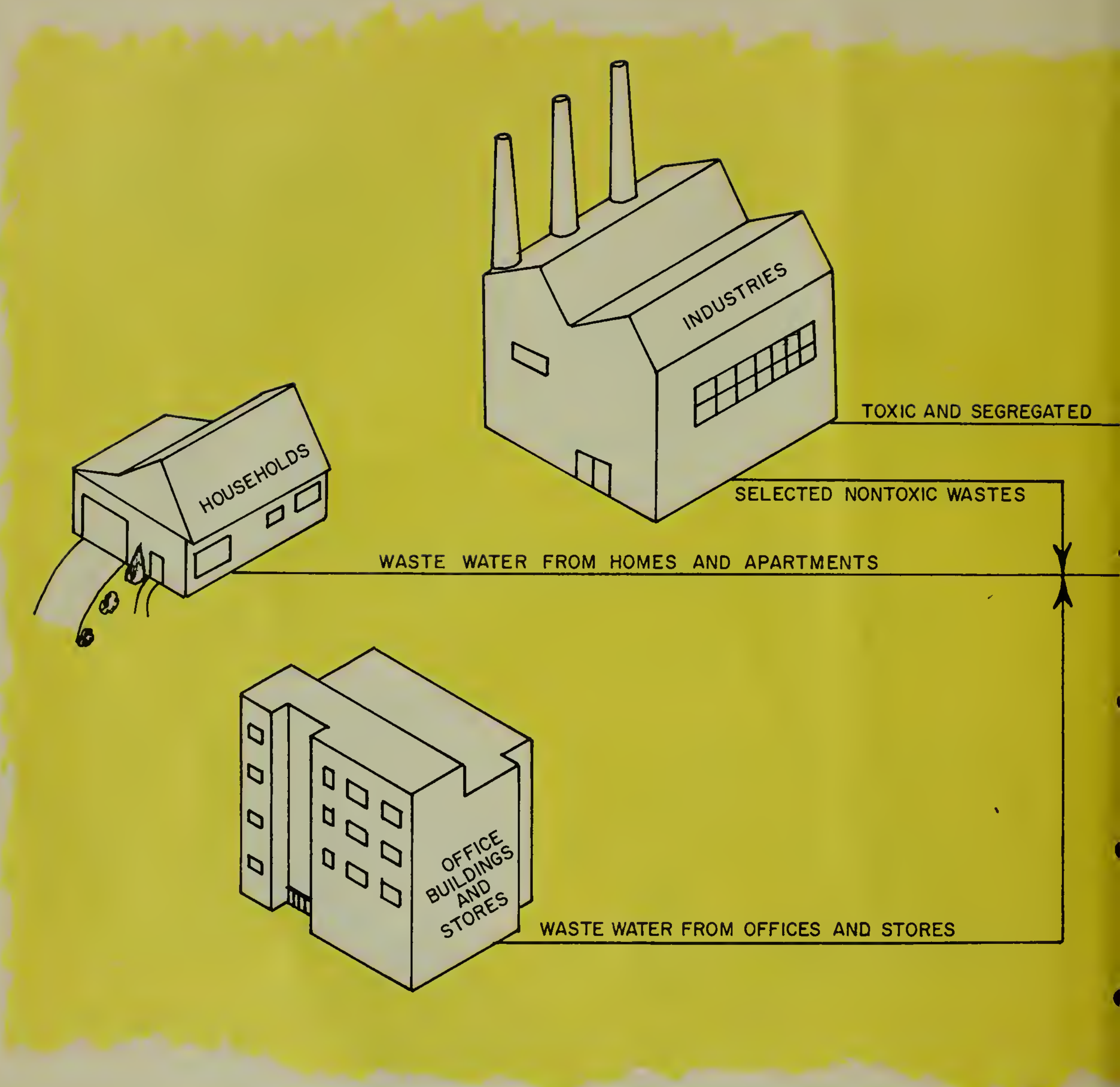
Additional Water Supplies

Not all of the waste water produced can be reclaimed and reused. In general, the amount that may be reclaimed for reuse is limited by the:

1. quality of the waste water;
2. cost of treatment;
3. cost of conveyance and distribution in the area where it will be used;
4. price that users are willing and able to pay;
5. need to leave sufficient flow to transport waste residues to a disposal site.

However, the detailed economics of waste water reclamation are not a part of this bulletin, which provides a brief look at the objectives of reclamation, the

* A glossary of terms is presented on page 41.

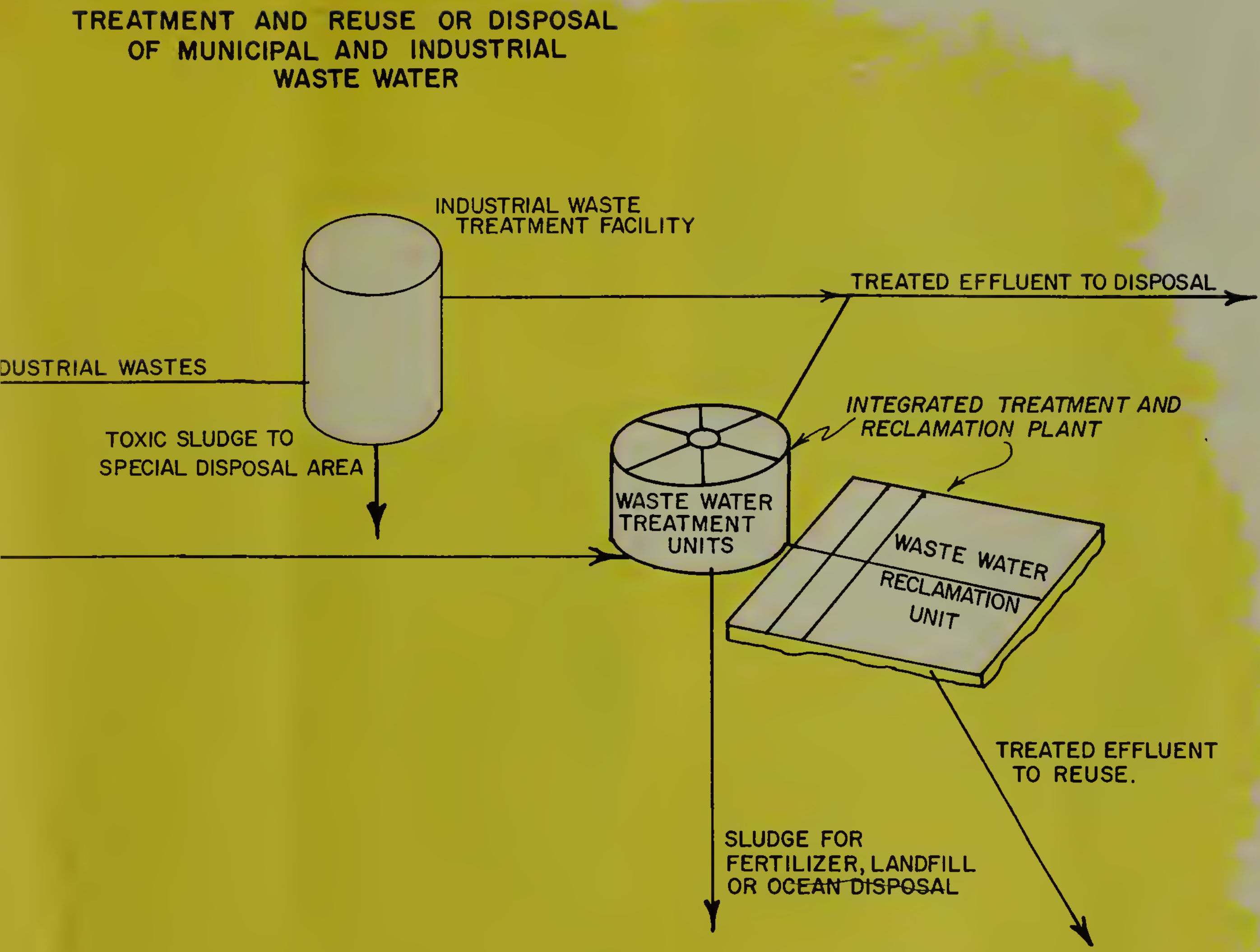


benefits to be derived, the treatment processes involved, and the status of reclamation today. In addition, Chapter V presents a brief projection of the future of waste water reclamation in California.

The practicability of reclaiming waste water in any given instance depends on a number of variables. One of these is the suitability of a particular type of waste water for a particular use in a given location. Another is the costs of the additional treatment required to "upgrade" the water for this particular use. A third variable is a demand for water to satisfy this particular need. Another consideration is the availability and cost of an alternative supply that could be used to fulfill this same demand. Still another factor is the cost of transporting the treated water to the point of reuse.

Consider, for example, the practicality of using agricultural waste water in the San Joaquin Valley for cooling powerplants. Such a concept would require consideration of all the factors described in the preceding paragraph. These would include:

- Is the technology available to "upgrade" agricultural waste water, which is highly mineralized, for use as evaporative cooling water?



- What will be the costs of the additional treatment required?
- Will there be sufficient demand for this water at locations where it is produced?
- Is another source of cooling water available at a lower cost?
- What will be the costs to transport the treated water to the powerplant?

At present, only about 8 percent of the 2.4 million acre-feet of municipal and industrial waste water produced annually in California is reclaimed and reused for such purposes as irrigation, industrial processing and cooling, recharge of ground water basins, and creation of recreational and ornamental lakes. An additional 15 percent finds its way into natural waters after disposal and is thus reused (although this is not considered true reclamation). However, as supplemental water becomes more scarce and more costly, as reclamation processes are improved, and as requirements for the discharge of wastes become increasingly stringent, greater amounts of waste water will undoubtedly be reclaimed and reused.

Scenic Recreational Boating in Golden Gate Park
A demonstrated use of reclaimed waste water

Waste water containing toxic and corrosive chemicals, such as mercury, arsenic, boron, phenols, chromates, and spent acid or lye, may be unsuitable for reclamation. However, the concentration of dissolved minerals (total dissolved solids) in waste water is generally the most important consideration in determining its suitability for reuse. For most uses, total dissolved solids should not exceed 1,000 parts per million (ppm), which is generally considered the upper limit for irrigation water. The recommended limit for drinking water is 500 ppm.

However, statistics in this bulletin were developed on the basis that waste water containing fewer than 1,500 parts per million of dissolved solids might be suitable for reclamation.

There are several reasons for consideration of this higher limitation:

1. Waste waters with a high dissolved solids content might be reclaimed and blended with high-quality water to produce acceptable supplies. For instance, water from the State Water Project will be available in Southern California, and could be blended with local supplies, or with reclaimed water, in areas where local water supplies are highly mineralized.

2. Waste water containing excessive total dissolved solids might be demineralized.

3. Mineralized waste waters are potentially suitable for certain uses, such as industrial cooling or the creation of recreational lakes.

Factors Limiting Reclaimed Water Use

The direct use of reclaimed water for domestic needs is not practiced in California because public health authorities are uncertain that virus and other disease-producing agents can be eliminated from waste water.

The results of recent public-opinion surveys on the use of reclaimed water indicate that the majority of those questioned favored its use for (1) industrial cooling and other operations; (2) irrigation of crops, parks, freeway landscaping, and golf courses or (3) supplies for ornamental and recreational lakes. On the other hand, as might be expected, opposition to the use of reclaimed water increased significantly with the likelihood of personal use, e.g., drinking, cooking, bathing, and laundering. In one particular statewide survey, only 0.8 percent of 972 persons questioned opposed the use of reclaimed water in road construction. However, 56.4 percent of the same group opposed its use as drinking water.

Indian Creek Reservoir in Alpine County
Reclaimed Water for Irrigation and Recreation

The American Water Works Association* has recently issued a policy statement on waste water recla-

* A national association of scientists and engineers, water suppliers, and equipment manufacturers devoted to the provision of safe and adequate water supplies.

mation. While recognizing that properly treated waste water constitutes an increasingly important element of the total water supply, the Association believes that the direct use of reclaimed water for public water supplies should be deferred until research and development have demonstrated that such use will not be detrimental to public health.

New Treatment Processes—A Better Environment

Every use of water—in homes, in factories, on farms —results in a change of water quality. To return water of more acceptable quality to receiving waters, new methods of removing pollutants are constantly being developed and advanced. Techniques currently under investigation range from (1) extensions of biological treatment for the removal of nitrogen, a nutrient that stimulates the growth of algae and other aquatic plants, to (2) separation techniques such as adsorption, ion exchange, and chemical precipitation, for the removal of toxicants, organic chemicals, and other dissolved and suspended materials, including nitrogen and phosphorus.

These new processes will eventually enable a high degree of waste treatment and produce reclaimed water of a quality comparable to that of our present-day freshwater supplies. However, these new processes are also becoming increasingly expensive. Therefore, properly treated waste effluents may soon become increasingly valuable—too valuable to discard. Instead, these effluents will produce water than can be directly used for agriculture, industry, recreation, and, possibly, even for drinking. Such complete reclamation will then serve the dual objectives of a more desirable environment and supplemental water supplies.

History of Waste Water Reclamation

Sewers have been in use for at least 5,700 years. This is evidenced by the sewer arch at Nippur, India, which is thought to have been constructed about 3700 B. C. Archaeologists have found evidence of sewers constructed on the Mesopotamian Plain, near present-day Baghdad, in the 26th century B. C. In ancient Rome around 80 A.D., permission of the Emperor was required before excess water could be conducted away from the city, because some of that water was needed to flush the sewers.

Modern sewage treatment began in England around 1868, when Sir Edward Franklin developed the intermittent sand filter for the removal of solid material from sewage. The sand filter (Figure 1), along with sewage farming, could be called the forerunners of waste water reclamation.

Sewage farming is the use of waste water before it enters a receiving body of water. However, even in this case, the reclamation process is only incidental to treatment and disposal. Sewage farming, which was first practiced in the United States around 1880, is still in use. In 1968, 128 communities practiced sewage farming as a means of treating wastes; 56 of these communities are in California.

The first actual waste water reclamation plant in the United States was constructed in 1926 at Grand Canyon National Park in Arizona. This facility, an activated sludge plant, was designed to provide reclaimed water for disposal of wastes from park restrooms and for lawn sprinkling, cooling water, and boiler-feed water at the Grand Canyon powerplant. A short time later, in 1929, Pomona, California began providing treated water from its municipal sewage treatment plant to irrigate lawns and gardens. Today, that operation is carried out by the County Sanitation Districts of Los Angeles.

In 1931, San Diego Teachers' College began to irrigate lawns and shrubs with reclaimed waste water but has since abandoned the practice. The City of San Francisco has been using reclaimed water from an activated sludge plant in Golden Gate Park since 1932. The water is used to irrigate lawns, shrubs, and gardens, and for several recreational lakes, within the park.

Harrington, Kansas supplied Rock Island Railroad steam locomotives with reclaimed water from the city's activated sludge plant from 1933 until the advent of the diesel engine ended the need. In 1942, the Bethlehem Steel Corporation at Sparrow Point, Maryland contracted with the City of Baltimore for 50 to 100 million gallons per day of sewage effluent for cooling and process water.

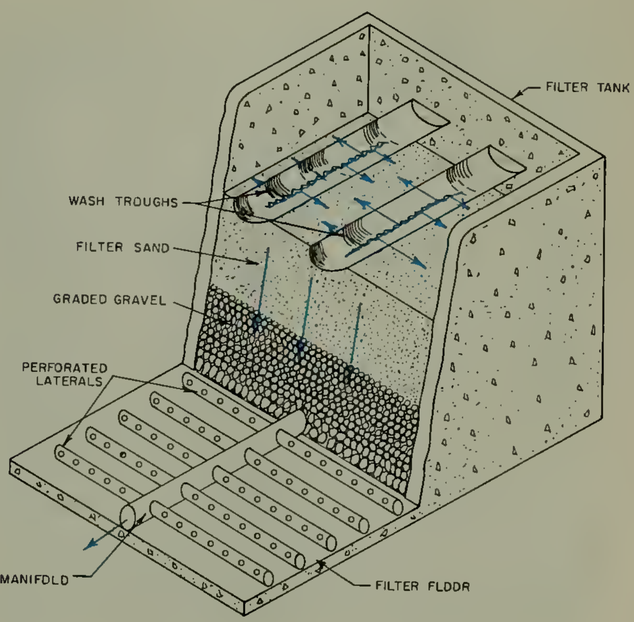


Figure 1. Rapid Sand Filter

In 1942, Kaiser Steel Corporation began operating a waste treatment facility at its Fontana, California plant, where about 750,000 gallons of both domestic and process waste water are reclaimed daily. This project was the first in California to be designed and constructed for the industrial reuse of reclaimed waste water. Moreover, it was the first plant to reuse reclaimed effluent (1) because of regulations restricting the discharge of wastes, and (2) as a source of cheaper water. In 1949, the Cogsden Petroleum Corporation Refinery contracted with Big Springs, Texas for about one million gallons per day of water reclaimed from its municipal activated sludge treatment plant.

Three more recently constructed reclamation projects in California include Whittier Narrows in Los Angeles County, Santee in San Diego County, and Indian Creek Reservoir at Lake Tahoe. The Whittier Narrows waste water treatment plant, which was constructed by the County Sanitation Districts of Los Angeles County in 1962, primarily to reduce the costs of waste disposal, reclaims about 15,000 acre-feet of domestic sewage annually for replenishment of downstream ground water.

At the Santee Project of the Santee County Water District, reclaimed water is used to maintain several artificial lakes and irrigate a golf course, and for several years, was used to fill a swimming pool. The Indian Creek Reservoir Project was completed by the South Tahoe Public Utility District in 1967 for the disposal of domestic wastes from the Lake Tahoe area. Tertiary-treated effluent from local wastes is transported through a 29-mile-long pipeline to Indian Creek Reservoir in Alpine County, which provides reclaimed water for recreation and irrigation of nearby ranches.

Whittier Narrows Reclamation Plant

Fishing at Santee

These three projects are described in greater detail in Chapter IV.

During 1970, 204 treatment plants were either in operation or under construction in California, and some 175,000 acre-feet of water was reclaimed, most of which was used for irrigation. Despite this recent increase in reclamation activity, however, the market for reclaimed water is still quite limited. Accordingly, reclamation and reuse of waste water are generally restricted to the jurisdiction of the waste-disposal agency carrying them out, which tends to limit both the type and location of possible reuse.

On the other hand, such restrictions and limitations will eventually be surmounted as treatment processes are improved and new sources of water become more scarce; and, particularly, as waste treaters and water suppliers become increasingly aware of their common goals—an improved environment and better management of water resources.

COMMON CONVERSION FACTORS

1 acre-foot (quantity of water that will cover 1 acre to a depth of 1 foot)	=	325,850 gallons
1 million gallons per day	=	1.55 cubic feet per second or 3.07 acre-feet per day
1 million gallons per day flowing for one year	=	1,120 acre-feet per year

State Plannng and Regulation

A number of state agencies are involved with the planning and regulation of waste water reclamation activities in California. For more than 40 years, the Department of Water Resources has included studies

of waste water reclamation in its water development planning. Whereas the Department of Water Resources is primarily concerned with planning and implementing reclamation activities, the responsibility for regulation and control of reclaimed water rests with the State Department of Public Health, the State Water Resources Control Board, and the nine Regional Water Quality Control Boards.

Department of Water Resources

In a 1930 report on the State Water Plan, the Division of Water Resources (predecessor of today's Department) stated that, if reclamation of sewage wastes were to prove feasible, as much as 500,000 acre-feet per year of the ultimate annual demand of 1,800,000 acre-feet in the South Coastal Basin could be supplied from reclaimed water by the year 2000.

The Statutes of 1949 specifically authorized the Department of Water Resources to conduct waste water reclamation studies and activities as provided in Section 230 of the California Water Code. Other broad authority is provided in Sections 12616, 12617, 12618, and 13530.* Since 1949, the Department's program has grown to include surveys and inventories of waste water reclamation potential and feasibility.

More recently, the Department has been expanding its program even further. In close cooperation with other state and local agencies, the Department will conduct studies to develop plans for specific waste water reclamation projects, including possible implementation by the State or through joint participation with local agencies. How such projects might benefit the environment will be an important part of these studies. The data developed will be an important part of the Department's continuous statewide planning for enhancement of the environment and management of California's water resources.

The Department's current reclamation activities include:

1. An annual statewide inventory of waste water production and reclamation practices and technology prepared from readily available data.

2. Studies in specific areas to (a) determine the possibility of using reclaimed water to both meet future water demands and solve water quality problems, (b) define specific waste water reclamation possibilities, and (c) determine how the use of reclaimed water will affect the environment and the ecological benefits that will result from such use.

3. Investigations and studies leading to (a) the implementation of waste water reclamation projects, or (b) a determination of the feasibility of reclaiming water from a specific waste or for a specific use.

A list of reports describing the Department's reclamation activities between 1950 and 1972 follows Chapter V of this bulletin.

* The California Water Reclamation Law is presented on page 42.

Other Calfornia Agencies

As far back as 1896, State health authorities began to regulate the use of waste water for the irrigation of specified crops. In 1918 the Department of Public Health adopted more stringent controls, one of which required a permit for the use of sewage for irrigation. These regulations also banned the use of raw sewage, or water polluted by sewage, for the irrigation of any crops, except fruits, nuts, and melons, that would be consumed without cooking. In 1933, these regulations were slightly revised to permit the use of highly treated and disinfected effluents for the irrigation of a wider range of crops.

In 1967, the California Legislature directed the Department of Public Health to ". . . establish statewide standards for each direct use of reclaimed water where such use involves the protection of public health". The new law also declared that the standards were to be imposed by the nine Regional Water Quality Control Boards.

The Porter-Cologne Water Quality Control Act of 1969 revised the 1967 law by directing the Department of Public Health to establish statewide *criteria* for the use of reclaimed water that would ". . . result in reclaimed water safe from the standpoint of public health, for the uses to be made". At the present time, the Department of Public Health is developing these criteria, which will include quality standards for reclaimed water intended for irrigation, industrial use, and recharge of ground water. However, the criteria will not include standards for the direct use of reclaimed water for human consumption.

The Porter-Cologne Act strengthened the role of the state and regional boards by requiring any agency reclaiming, or proposing to reclaim, waste water to file a report with the appropriate regional board. The nine regional boards are responsible for enforcement of the criteria established by the Department of Public Health.

The Porter-Cologne Act also authorizes the State Water Resources Control Board to provide loans for studies and investigations in connection with the reclamation of waste water. The State Board has taken an aggressive role in encouraging the development of reclamation facilities.

Section 2133 of the California Clean Water Grant Regulations prescribes that water reclamation facilities shall be encouraged and that grants shall be made available for such facilities if reclamation and reuse are shown to be an economical long-range solution to pollution problems. In addition, under Section 201 of the Federal Water Pollution Control Act Amendments of 1972, waste water reclamation is recognized for the first time as a valuable adjunct to water treatment. Agencies proposing to include reclamation facilities as a part of treatment and disposal systems may receive priority in qualifying for the combined federal-state grants.

II. WHAT IS WASTE WATER RECLAMATION?

Waste water reclamation projects are sometimes implemented as a means of waste disposal, i.e., the primary purpose of the project is to dispose of treated effluent while the beneficial use derived from the effluent so discharged is incidental. However, in this bulletin, the term "waste water reclamation" means the planned renovation of waste water with the intent of producing usable water for a specific beneficial purpose. The California Water Code defines reclaimed water as "... water which, as a result of treatment of waste, is suitable for a direct beneficial use or a controlled use that would not otherwise occur."*

Reclamation projects reduce discharge of pollutants to the environment and produce water of suitable quality for certain uses. Reclaimed water increases the utility of available water supplies and may be used to fulfill certain water demands or to permit other water supplies to be used for other purposes.

Treated waste waters disposed to land and to streams and rivers remain in the usable water cycle, and almost all are reused incidentally. However, the reclamation of waste water that would ordinarily be discharged to saline waters would result in a "new" source of water —water that, without reclamation, would be lost to the usable fresh water cycle.

* Section 13050 (n)

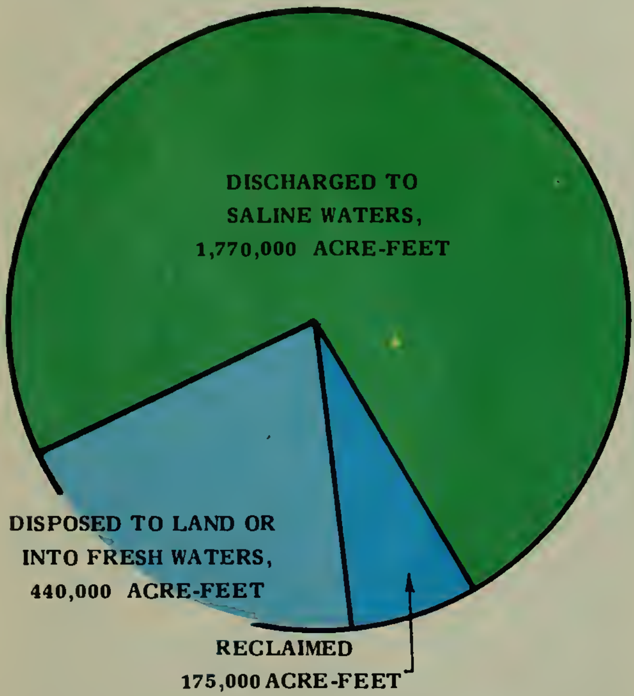


Figure 2. Disposition of Municipal and Industrial Waste Water Produced in 1970

Figure 2 shows the disposition of treated waste water discharged in 1970. As shown, almost ¾ of the 2.4 million acre-feet of treated waste effluent produced during 1970 was discharged into the ocean and into saline bays and estuaries. It is the reclamation of this waste water (1.77 million acre-feet in 1970) that offers potential as a "new" source of water.

Uses for Reclaimed Water

The reclamation and use of waste water may be planned or it may occur only incidentally, or a combination of these objectives may be developed. Planned use of reclaimed water is the deliberate direct or indirect use of reclaimed water by the treating or disposing agency, or by anyone who wants to use it. Frequently, the users will pay a significant part of the costs of treatment.

Incidental water reuse is the unplanned direct or indirect use of treated waste water following disposal. An example of incidental reuse is the disposal of treated waste water to a receiving stream and subsequent reuse as part of the general water supply.

Recycling is the direct reuse of water, without treatment, at the same general location, or for the same purpose, and is not considered reclamation. For example, recycling occurs when irrigation runoff is returned and mixed with the available supply and then reused. Another example is the use of recycled water in an industrial cooling tower. Although the cooling water is continuously recycled and reused, additional water must be introduced because (1) some of the cooling water evaporates, and (2) some of the water becomes excessively mineralized and must be discharged.

At present, reclaimed water is used chiefly for agricultural, industrial, municipal, and recreational pursuits. Agricultural uses include the irrigation of (1) pasture, (2) fodder, fiber, and seed crops, (3) crops that are grown well above the ground, such as fruits, nuts, and grapes, provided they are not harvested after they have fallen, and (4) crops that are processed so that pathogenic organisms are destroyed prior to human consumption.

Industrial uses of reclaimed water include cooling water, process wash water, boiler feed water, quenching spray water, fire protection, and secondary product recovery. These are carried out chiefly at metallurgical manufacturing and fabrication plants, electric-power generation plants, oil refineries and petro-chemical plants, and in mining and quarrying.

The direct use of reclaimed water for municipal and recreational pursuits includes (1) irrigation of

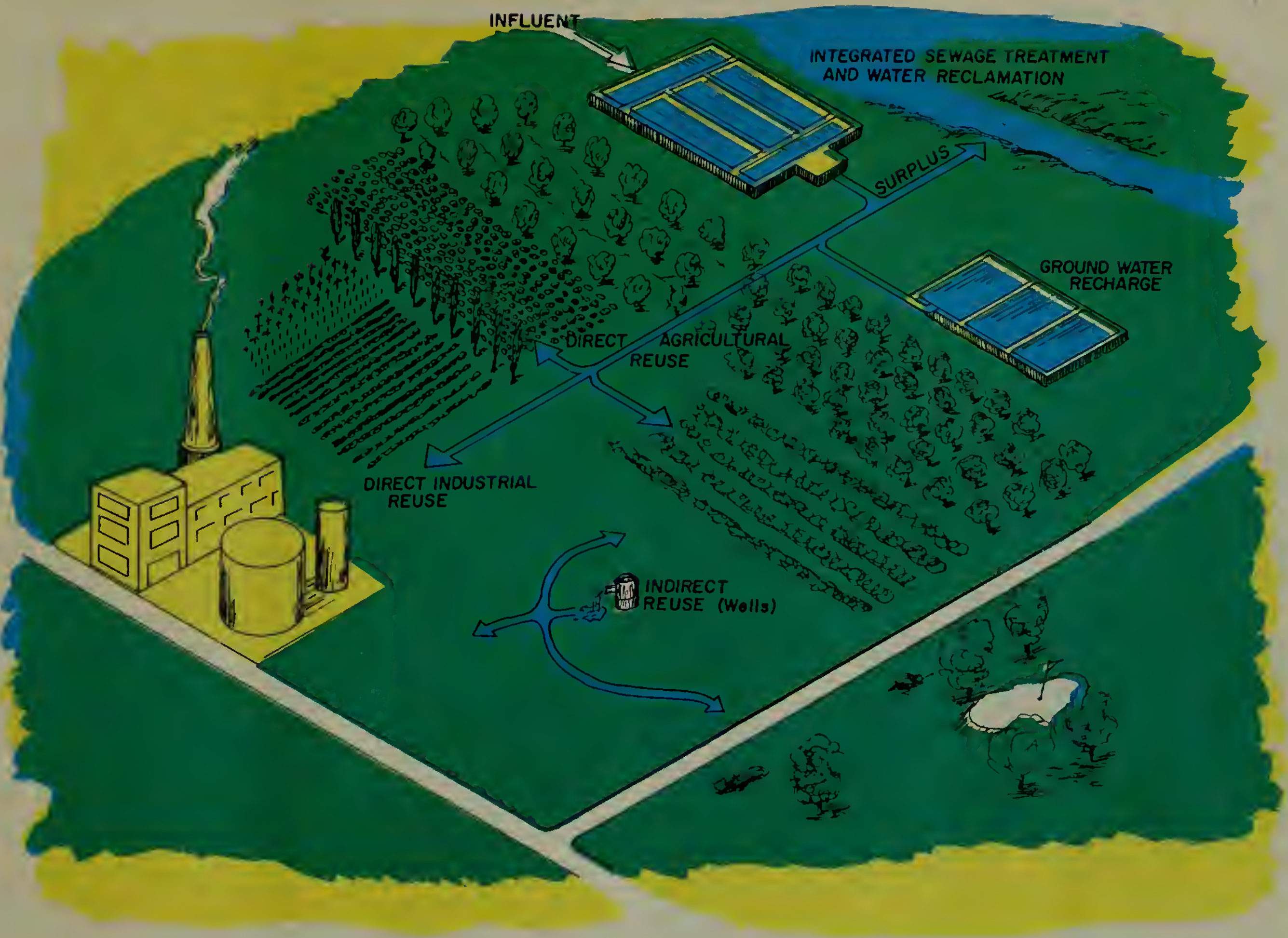


Figure 3. Direct and Indirect Use of Reclaimed Waste Water

parks, freeway landscapes, golf courses, and athletic fields; (2) creation of scenic and ornamental lakes and ponds; (3) the maintenance of recreational lakes—for picnicking, boating, swimming, etc; and (4) irrigation, fire protection, and cooling water at thermal powerplants and industrial plants.

In 1970, over 90 percent of the waste water reclaimed in California was used directly, or indirectly, for irrigation. Only two percent was used for industry. The remainder was equally divided between municipal-irrigation and recreational uses. Figure 3 represents schematically (1) the direct use of reclaimed water for industry, agriculture, and ground water recharge, and (2) the indirect use of reclaimed water that has been percolated into a ground water basin and made available in a well.

Factors Governing The Use of Reclaimed Water

Decisions as to whether to discharge waste water to a stream or river, or to reclaim it, must include consideration of:

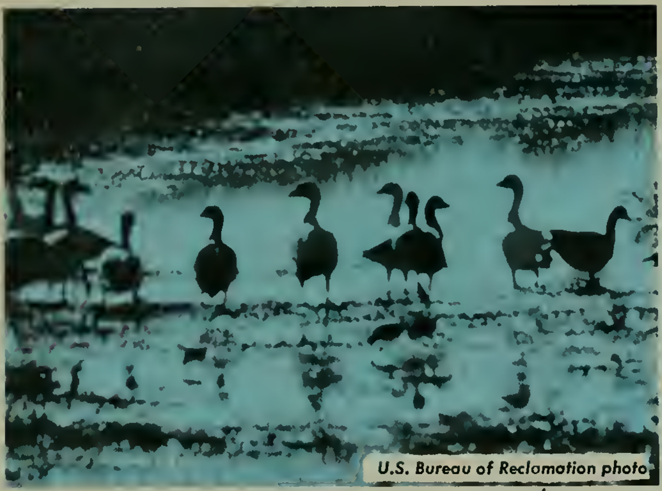
- Quantity and quality requirements.
- Legal rights—who owns the reclaimed waste water?
- Economics—waste water markets and supply.
- Public acceptance of reclaimed water.
- Environmental consequences of discharge to a natural body of water.

Quantity and Quality Requirements

Quantity and quality standards for all potential uses of reclaimed water cannot be precisely defined because requirements for various uses will generally differ in the various locales where reclaimed water may be used. However, requirements will generally be similar to those governing the use of natural water supplies.

First of all, sufficient dependable quantities of reclaimed water must be available to warrant its use. In some cases, storage may be necessary to ensure that adequate water is on hand for the intended purpose.

Possible Uses for Reclaimed Water



Wildlife Pond ← Duck pond!

Powerplant Cooling

Vineyard Irrigation

As an example, for cooling water in a thermal powerplant, a dependable supply of 20,000 acre-feet per year—or more, depending on both the quality of the reclaimed water and the type of plant—would be required for each 1,000 megawatts of installed capacity.

The quantity of reclaimed water needed for any particular use is often affected by its mineral (dissolved solids) content. Generally, the higher the mineral content, the greater the quantity that will be required. Referring again to thermal cooling, when the city of Burbank began using reclaimed water for this purpose, the water requirement per megawatt of installed capacity increased about 37 percent. This was due to the more frequent discharge of mineralized water required to prevent scale from forming on condenser coils.

When reclaimed water is used for the recharge of a ground water basin, the amount that can be stored may be limited by (1) the quality of the reclaimed water, the quality of the receiving water, and the desired quality of the blended water; (2) the permeability and transmissibility of the soil; and (3) the storage capacity of the ground water basin. These factors determine how fast*—and how much—water can percolate into the ground water and, once it reaches the ground water body, how quickly it can reach the point of intended reuse and how much can be stored for future use.

Quality standards for all uses of reclaimed water must be established to protect the public health and safety and to ensure that the water will be satisfactory in all respects for the intended use. After proper treatment, reclaimed water can be used in lieu of other water supplies for many uses.

For example, much of the waste water produced in California could be satisfactorily treated and used for the irrigation of crops. However, highly mineralized waste water must be demineralized, blended with natural water before application, or used for the more salt-tolerant crops only.

On the other hand, because of the paramount need for protection of the public health, the direct use of reclaimed water for domestic consumption cannot be considered at the present time. However, for many years, treated waste waters have been used indirectly after dilution in rivers or percolation into ground water. The filtration of ground waters and their normal considerable residence time before use afford natural purification of treated effluents. However, dilution in surface water offers far less assurance of natural purification, and additional treatment is necessary.

* These times may be measured in months or years depending on the characteristics of the ground water basin.

Standards related to organic and nutrient characteristics are intended to preclude objectionable conditions. These include consideration of such factors as the reduction of (1) suspended matter in ground water, (2) suspended organic matter in surface water, to prevent excessive depletion of dissolved oxygen, and (3) nutrients in surface water to preclude the growth of unsightly algal blooms.

Who Can Reclaim Waste Water?

Under California water rights law, anyone who has the right to divert and use water also has the right to reclaim and reuse waste water (from the supply so diverted) for beneficial purposes, subject to certain established rights of downstream appropriators. Moreover, anyone who produces waste water, and who is responsible for treating that waste water before it is discharged, may (1) reclaim and reuse the waste water in his possession, or (2) sell reclaimed waste water for use by others.

Those who may reclaim and reuse waste waters include cities, counties, sanitary districts, sanitation districts, county water districts, community service districts, irrigation districts, and special water districts. Any state agency or installation, or any federal agency or installation, which produces and treats waste waters can also reclaim and reuse these waste waters. In addition, commercial establishments, housing units, subdivisions, commercial complexes, and many more, may treat waste water for reuse. –

Any producer of waste water who is required to treat this water before discharging it may elect to reclaim and reuse it.

Waste Water Markets and Supply

Waste water reclamation will be feasible only if a market for the reclaimed water is available. To minimize transportation costs, the reclamation facilities should be located as close as possible to the potential market.

The supply of waste water must be sufficiently large, and of suitable quality, to be susceptible to reclamation by treatment processes to the degree necessary for the intended use. Generally speaking, the lower the dissolved mineral content of waste water, the more suitable it will be for reclamation.

Therefore, whenever possible, wastes (1) with a high dissolved mineral content, (2) containing toxic material, or (3) which are otherwise unsuitable for, or unresponsive to, conventional waste-water treatment processes should be excluded from the supply intended for reclamation. This is an important economic consideration because:

Irrigation of Cotton near Fresno
Another possible use for reclaimed water

Industrial Use

Golf Course Irrigation

- The cost of reclaiming better quality water is lower, and
- Users will pay a higher price for better quality water.

Public Acceptance of Reclaimed Water

Large-scale reclamation of waste water as a "new source" of usable water supplies will be possible only if the citizens of California, and other states, will accept and support it. And, as pointed out in Chapter I, a recent sampling of public opinion indicated that many Californians would accept reclaimed water supplies, although not immediately for direct personal uses such as drinking, cooking, and bathing.

A natural reluctance to use "somebody else's wastes" is understandable. However, the successful reclamation projects described in Chapters I and IV demonstrate that satisfactory water supplies can be produced for a number of uses—industry, irrigation, recreation, and replenishment of ground water.

Environmental Consequences of Discharge to Natural Waters

Until recently, the chief concern of those who planned water development projects was the direct cost of making water available. Today, however, that concern includes assurance that the quality of the environment will be protected and enhanced. And, waste water reclamation projects will help provide a cleaner environment by reducing the sources of waste discharge as they increase the sources of water supply.

Actually, water is indirectly reused every day as waste water mingles with natural waters and is indirectly reused downstream. In Northern California, for example, as the American River moves toward its confluence with the Sacramento, its waters are used and reused at several locations. The waste treatment plants along the way, dilution, and the natural purification processes of the river, combine to make the discharged waste water suitable for reuse after conventional treatment.

Today, however, the concept of planned reclamation—taking water from a waste treatment plant and putting it to direct use without returning it to a stream or river—has become a part of modern-day water management. Naturally, no reclamation project can be successful without consideration of the public health and safety, and the waste-discharge requirements imposed by the nine regional water quality control boards provide increasing protection for both the public and the State's receiving waters.

A few years ago, most communities were able to discharge waste water after primary treatment only. Today, many of these same communities are required to provide secondary treatment. As time passes, the State's requirements for waste discharge will probably provide even greater protection of both the environment and the welfare of the public.

As reclamation technology is improved, and the requirements for disposal of waste water become more stringent, the outlook for waste water reclamation will become increasingly favorable, and the use of reclaimed water will become more acceptable to the public and increasingly desirable.


U.S. Bureau of Reclamation Photo

III. HOW IS WASTE WATER RECLAIMED?

The basic objective of waste treatment is to remove or neutralize pollutants that have been added to water during municipal, industrial, agricultural, and other uses, so that the treated water can be safely discharged to the environment or reclaimed for reuse. Waste water treatment for disposal differs from that for reuse only to the extent that requirements for reuse differ from those for disposal. The requirements for reuse may be more stringent than those for discharge to rivers, i.e., additional treatment is usually needed. However, this is not always true; for example, nutrients in waste water may produce excessive algal growths in receiving water, but would pose no problem if the treated water were used for irrigation.

Treatment of waste water begins with the collection and transportation of wastes. In most instances, collection systems for municipal and industrial waste waters are separate from those for storm water and surface runoff. Today, only five percent of all municipal sewer systems in California are combined, i.e., carry sewage, surface runoff, and storm water in a single sewer to a treatment plant. A serious disadvantage of combined systems is that during periods of heavy rainfall, the treatment system can become overloaded; at such times, part of the combined flows may bypass the treatment plant and be discharged without treatment.

The treatment required depends on both the character of the waste water and the intended use. Municipal wastes include sewage and other waste substances associated with human habitation, of animal origin, or from any producing, manufacturing, or processing operation. Most municipal wastes contain minerals, organic oxygen-consuming substances, pathogenic bacteria and virus, and, in some cases, toxic material and heavy metals. For most uses, the oxygen-consuming matter must be partially removed and the bacteria and virus essentially eliminated.

The character of industrial waste waters varies widely. Some industrial wastes may be unsuitable for reclamation. They may be toxic or their properties may hinder or disrupt ordinary treatment processes. In such cases, heavily polluted waste water should be excluded from the sewerage system. However, if source control is impossible, undesirable wastes should be segregated and treated before discharge into the municipal collection system.

In some treatment systems, waste waters intended for reclamation are processed differently than are those intended for disposal. In others the same processes are used to treat wastes for both disposal and reclamation. The greater the direct human contact involved in the use of reclaimed water, the higher the level of treatment required.

For example, to produce water for irrigation of golf courses, parks, greenbelts, ornamental lakes, etc., removal of suspended material, along with disinfection to control pathogenic organisms in the treated effluent, may be the only treatment required. On the other hand, if the water is to be used for the irrigation of produce, an extra stage of filtration to remove fine suspended materials and additional disinfection probably would be required.

For industrial reuse, including cooling water, the selective removal of corrosive or scale-producing components may be needed to protect processing equipment or to prevent interference with plant processes. When recreation is the intended use, the renovation usually includes removal of nutrients to control algal growth, elimination of solid material for aesthetic reasons, and disinfection for health protection.

Agricultural drainage contains varying amounts of salts and other materials from the original supply water concentrated by evaporation and plant use, some additions from soil leaching, and fertilizers and pesticide residues. The excess runoff from irrigated fields, called tail water, often contains about twice the salt concentration of the supply water. Tail waters are often returned directly to the streams, ground water, or canals for further use. In many areas of California, these return flows become a significant part of the water supply.

When the drainage waters become too salty for further use, they are termed agricultural waste waters. Such waters are often found where the supply water is highly saline, particularly in (1) areas dependent on Colorado River water (2) areas of poor drainage and alkaline soils such as the west side of the San Joaquin Valley, and (3) closed basins such as the Tulare Lake basin. Agricultural waste waters are often collected in underground tile drainage systems, isolated from the supply system, and exported to a disposal area.

Agricultural return flows also frequently contain nitrogen, from fertilizers and other sources, which tends to encourage the growth of algae and other aquatic organisms and plants. Economical processes for the reduction or removal of nitrogen from agricultural waste water are now the subject of intense research in California and in other parts of the world as well.

For most uses, except for some industrial cooling processes, recreational pursuits, and wildlife ponds, agricultural waste water must be demineralized. At the present time, the removal of salts from agricultural waste water is also being extensively researched. When cooling water is the intended use, some softening or removal of corrosive or scale-producing components may be required, along with provisions to control or-

WASTE WATER TREATMENT PROCESSES

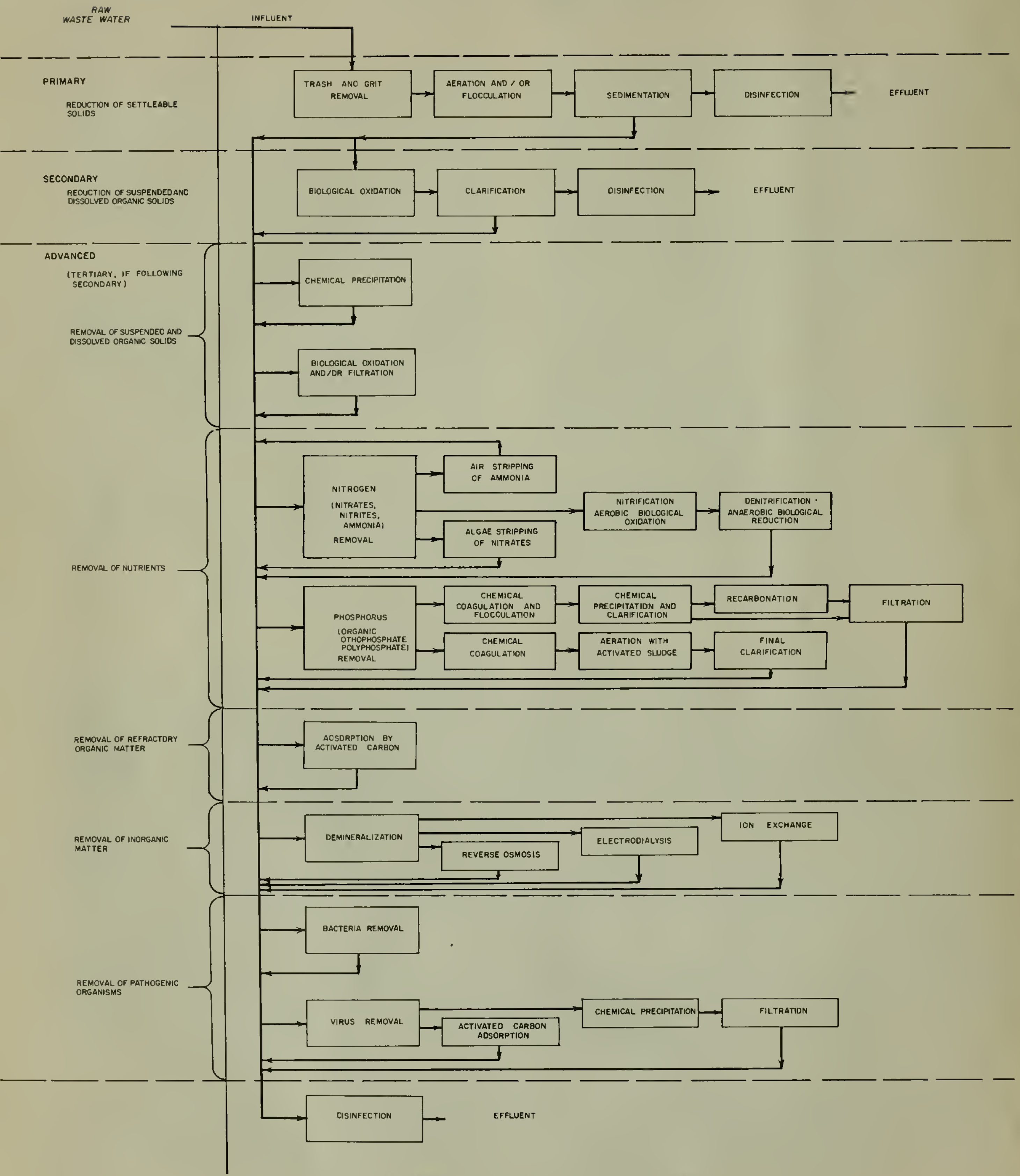


Figure 4. Alternative Processes in Waste Water Treatment

ganic growths. Use for recreational lakes or wildlife ponds may require only the removal of nutrients and pesticides.

Treatment Processes

Requirements for the proposed use and the quality of the waste water define the type or level of treatment needed for any type of waste. For each proposed use, the treatment process must be tailored to the specific need.

Treatment of municipal wastes is usually described as primary, secondary, and advanced or, if following secondary, tertiary. Primary treatment includes such physical processes as settling and skimming to remove gross impurities. During secondary treatment, biological processes are used to reduce oxygen-consuming organic matter. Advanced treatment may include additional biological treatment, chemical precipitation, ion exchange, removal of nutrients, filtration, carbon adsorption, demineralization, and other special processes to further reduce impurities.

Figure 4 is a block diagram of the various degrees of treatment and the processes involved in each. These processes are described in the following paragraphs.

Primary Treatment

Primary, or the first stage of, waste water treatment removes some of the floating materials, substantial portions of the settleable solids, about half of the suspended materials, and from one quarter to one third of the organic material requiring oxygen for decomposition and stabilization. Figure 5 is a block diagram of the three general processes involved in primary treatment. Functions of the specific units involved in primary treatment are described in the following paragraphs.

The types and amounts of debris and miscellaneous materials that accompany sewage to a treatment plant include discarded shoes and clothing, tree limbs, and even small trees. Bar screens (Figure 6) are used to

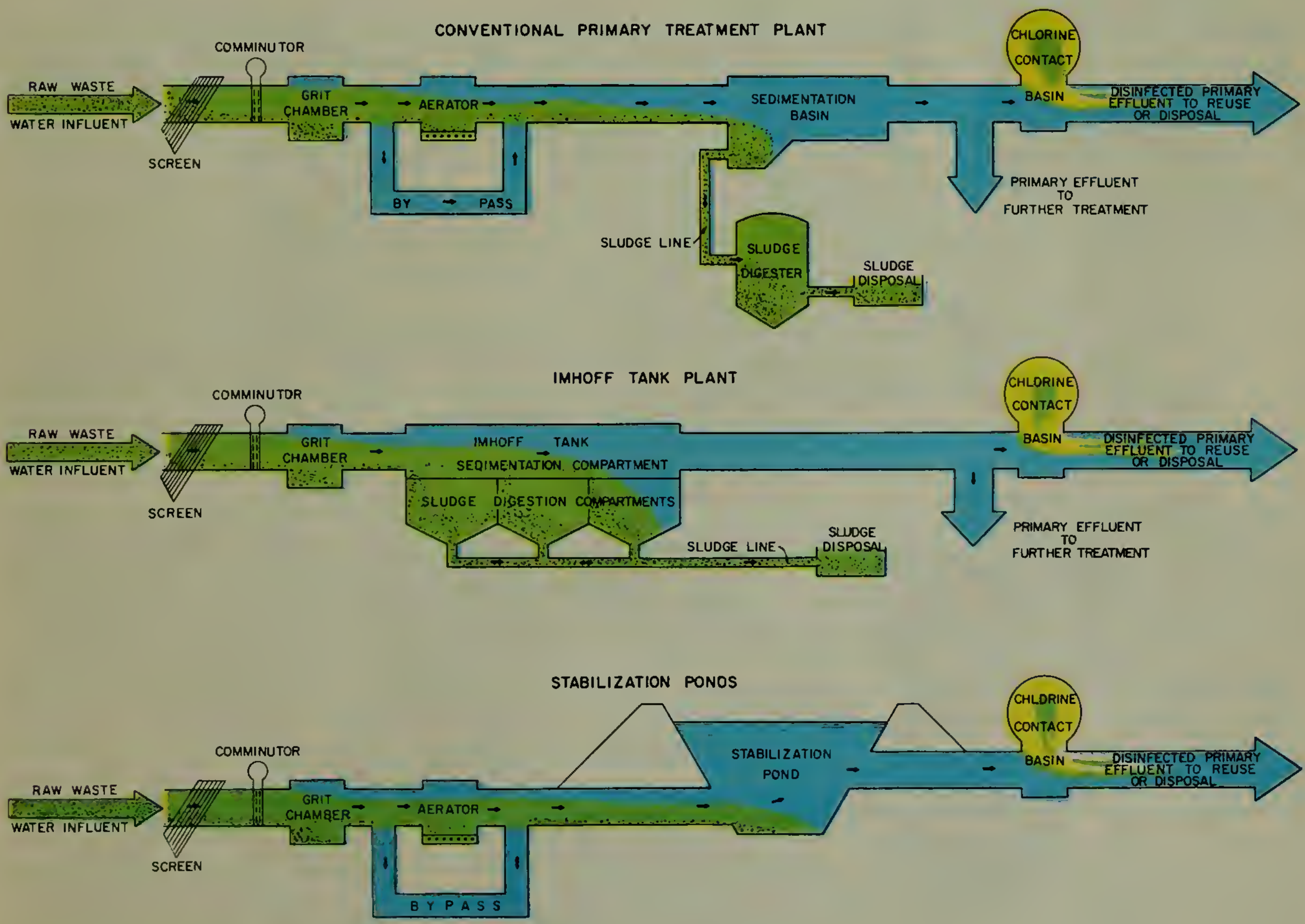


Figure 5. Primary Waste Water Treatment

intercept overly large debris from the influent sewage. These are then removed to prevent unsightly conditions in receiving waters; to enable more effective disinfection, as overly large particles cannot reliably be disinfected; and, most importantly, to protect mechanical devices used in the treatment process. Large pieces of organic material are chopped up as they pass through the comminutor, which is simply a grinder located in the waste water stream (Figure 7).

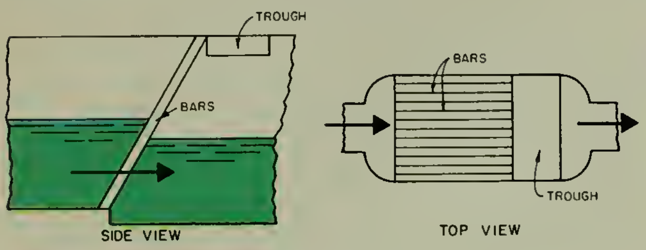


Figure 6. Bar Screen

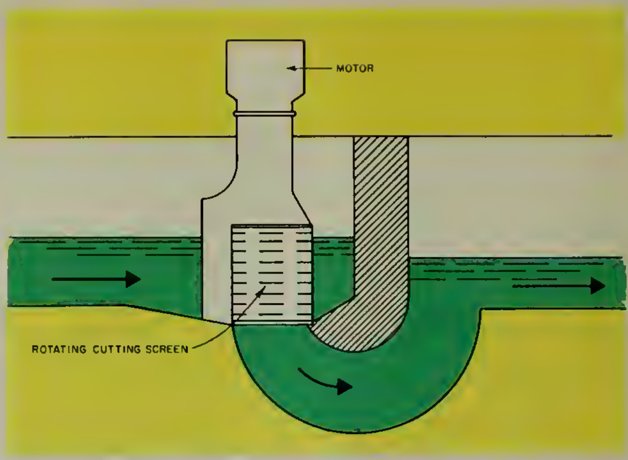


Figure 7. Comminutor

Santee County Water District photo

Aeration Basin

Grit chambers (Figure 8) are included to settle and remove sand and other heavy or inert materials, to protect pumps and other machinery used in the treatment process, and to reduce the amount of such materials that must be collected, handled, and stored during other phases of treatment. Pretreatment may also include aeration to clean organic material from the grit, to freshen the waste water, or to float oil, grease, and other solids so that they may be skimmed off.

After pretreatment, the waste water enters a sedimentation basin (Figure 9), where the rate of flow is reduced, and the quiescent conditions permit suspended materials to settle to the bottom. Plows or scrapers are used to move the settled materials to a central point, where they are transferred to a digester for further treatment; meanwhile, the waste water, now minus the settled material, is disinfected in a chlorine-contact basin (Figure 10).

Figure 8. Grit Chamber (side view)

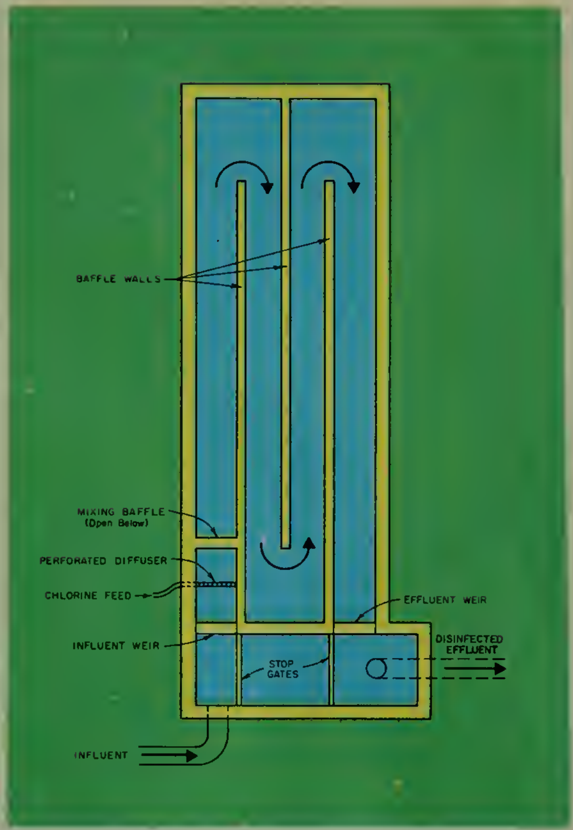


Figure 10. Chlorine Contact Basin (top view)

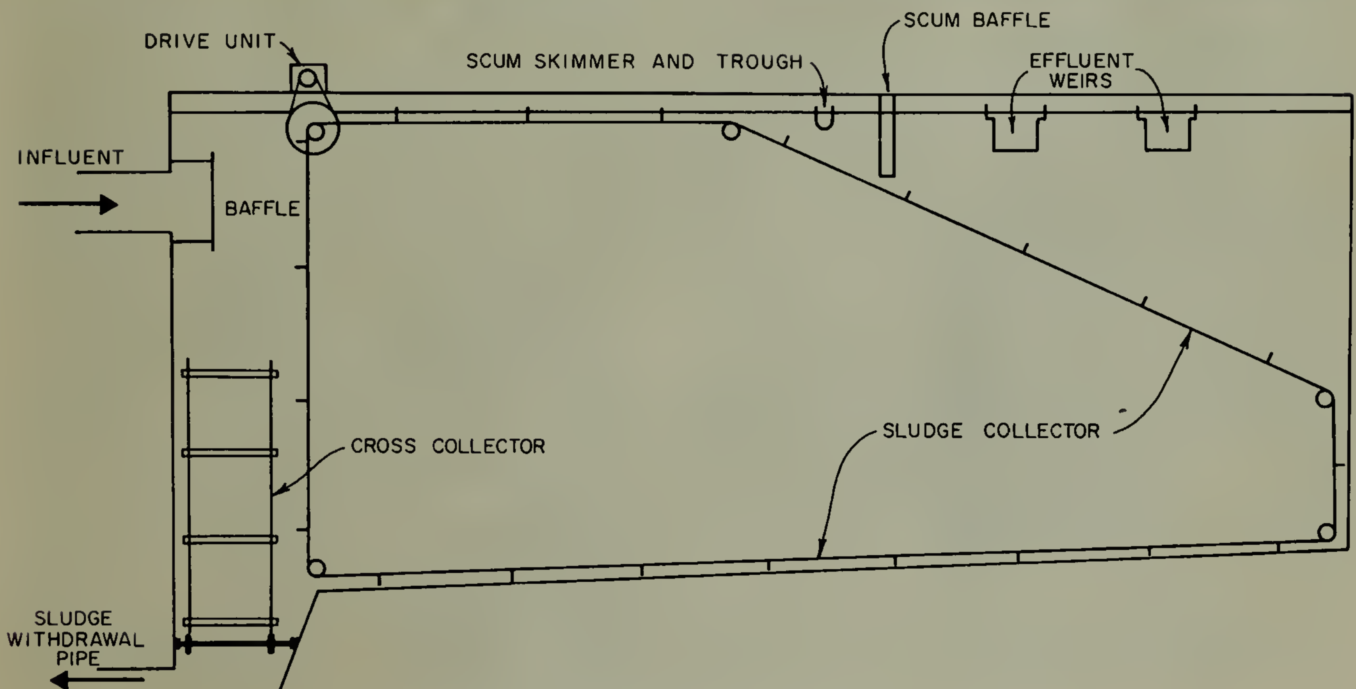


Figure 9. Rectangular Sedimentation Basin (side view)

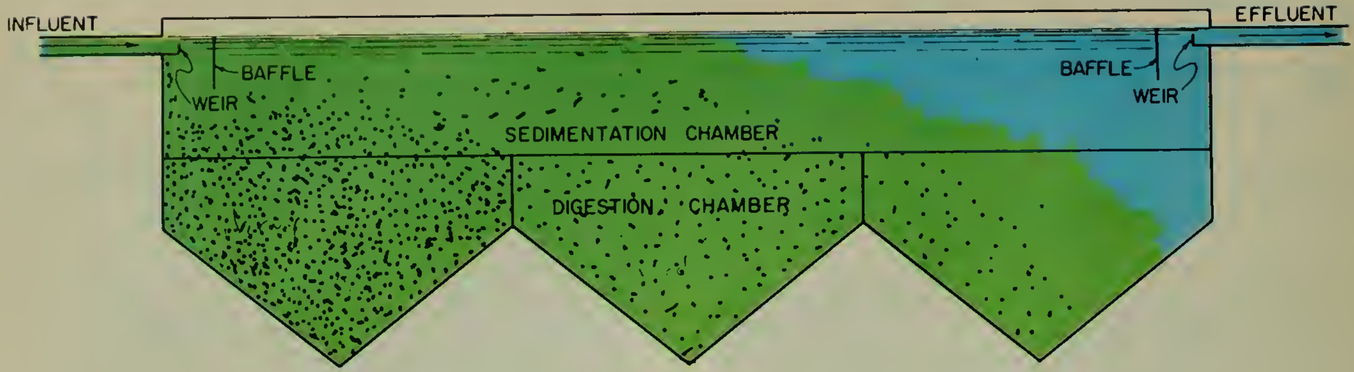


Figure 11. Imhoff Tank (side view)

A digester is used to anaerobically stabilize the solids removed from the sewage and permit their separation and concentration. The liquid portion is returned for reprocessing through the treatment plant. Periodically, the stabilized sludge is withdrawn from the digester and dewatered by allowing it to drain on sand beds, or by the use of filters and centrifuges. Heat drying may also be used as the final step in solids handling.

The disposal of sludge is a major problem. Provided it contains no toxic materials, dried sludge can often be used as a soil builder or fertilizer. However, because the demand for its use as a fertilizer or soil builder is limited, the surplus must be disposed of in some other way, such as in a landfill. Sludge that contains toxic materials from waste discharges is unusable, and must be disposed of in a manner that will protect the environment. However, in most cases, municipal sludge is a satisfactory soil conditioner.

A two-level, three-compartmented Imhoff tank (Figure 11) has been used in past years for a combination of sedimentation and solids digestion. The top level contains the sedimentation compartment, and digestion takes place in the lower compartment.

Stabilization ponds, which are frequently found in rural areas, represent a simple combination of primary and secondary (biological) treatment that may be acceptable under some circumstances. The shallow stabilization pond enables sedimentation and sludge digestion to take place simultaneously in a single unit. Periodically, each pond is drained, and the accumulated sludge is removed. Their principal advantage is low initial cost and simplicity of operation.

Primary effluent may be disinfected by chlorination and discharged, or it may be given further treatment.

Secondary Treatment

Secondary waste water treatment provides biological oxidation and assimilation of the organic matter remaining in the effluent after primary treatment. This is then followed by clarification. Almost all secondary treatment systems use trickling filters, the activated sludge process, or ponds for oxidation and assimilation. Flow diagrams of these three processes are shown in Figure 12.

A trickling filter (Figure 13), which can remove 70 to 90 percent of the organic loading of the original inflow to the treatment plant, is a bed of crushed rock, slag, field stone, or other media through which effluent from primary treatment passes. The filter media become coated with biological growths, which multiply and feed on organic matter in the waste water. The filtered water then passes to a final clarifier for sedimentation before disinfection and discharge. Sludge (or humus) from the clarifier is normally combined with sludge from the primary clarifier and pumped to the digesters.

Activated sludge is a flocculent suspension of bacteria and other organisms. The activated sludge process (Figure 14) can remove 85 to 95 percent of the organic matter from the original inflow to the treatment plant. In this process, as the biologic floc and air are mixed, bacteria and protozoa metabolize the organic matter. In the clarifier, the relatively clear supernatant is withdrawn over weirs, while the settled biologic floc is recirculated to the aerator. A small portion is usually returned to the primary clarifier, from which it is subsequently pumped to the digester system.

The activated sludge process is sometimes modified to include extended aeration and contact stabilization. These processes were developed to function effectively with intermittent loading and with relatively small flows such as those from schools, housing developments, trailer courts, etc. Activated sludge plants can be designed and operated to convert ammonia nitrogen to nitrate; a recent development of this concept indicates that an additional biological step can be used to convert nitrate-nitrogen to nitrogen gas, thus completely removing this nutrient from a waste water.

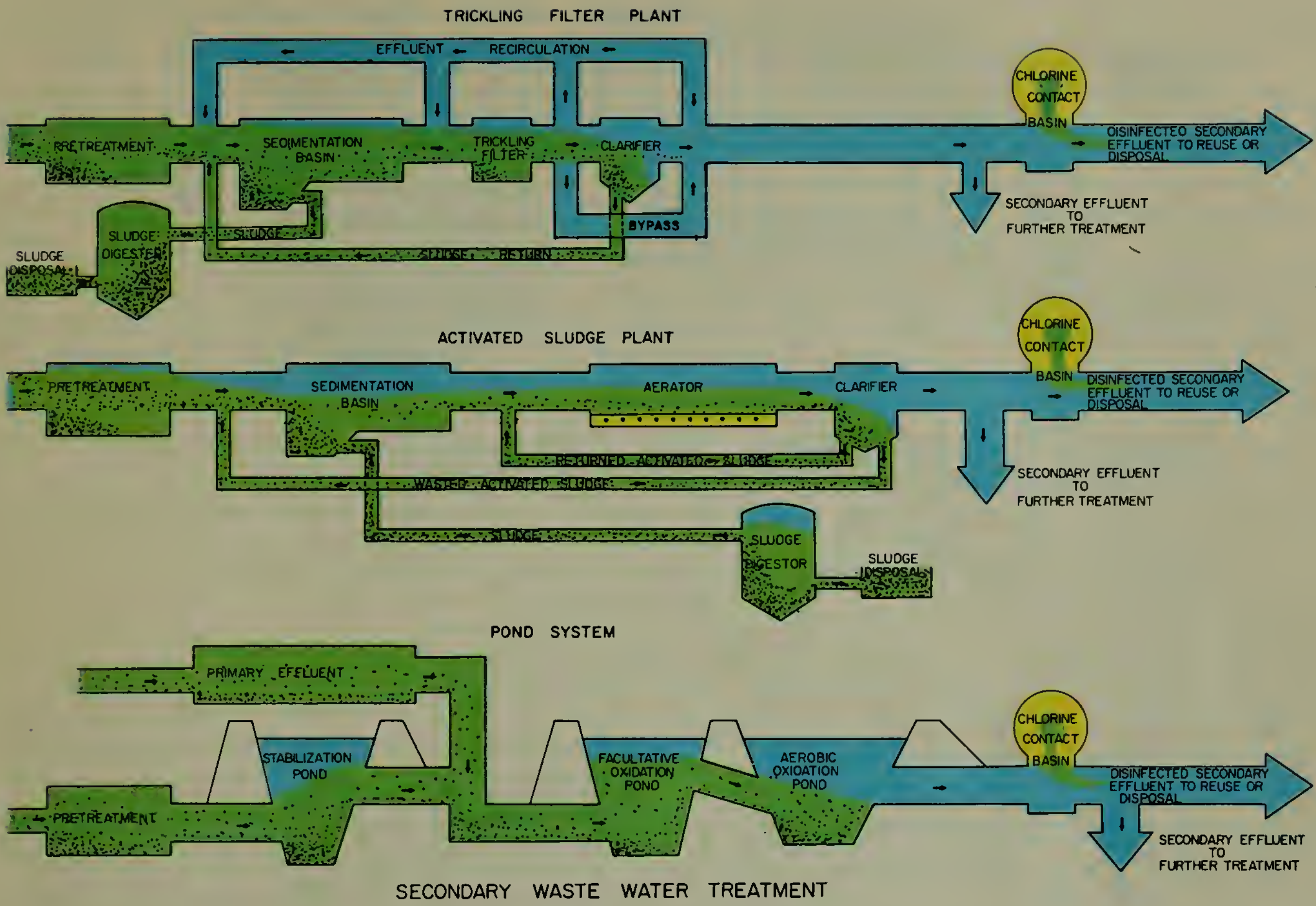


Figure 12. Secondary Waste Water Treatment

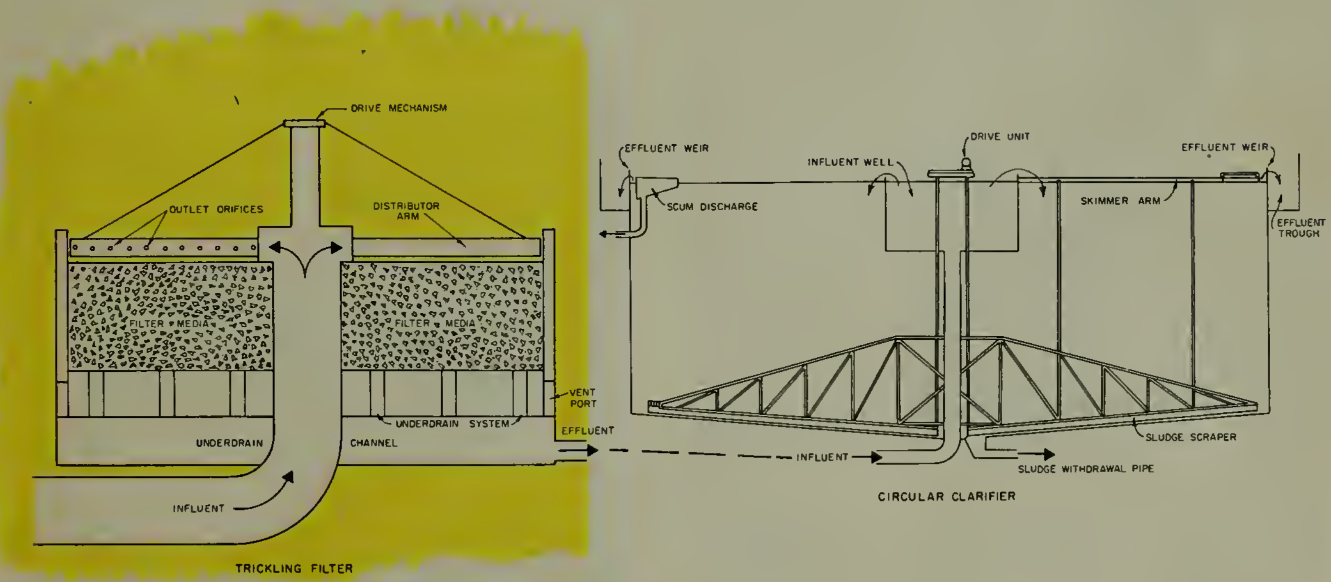


Figure 13. Trickling Filter with Discharge to Clarifier (side view)

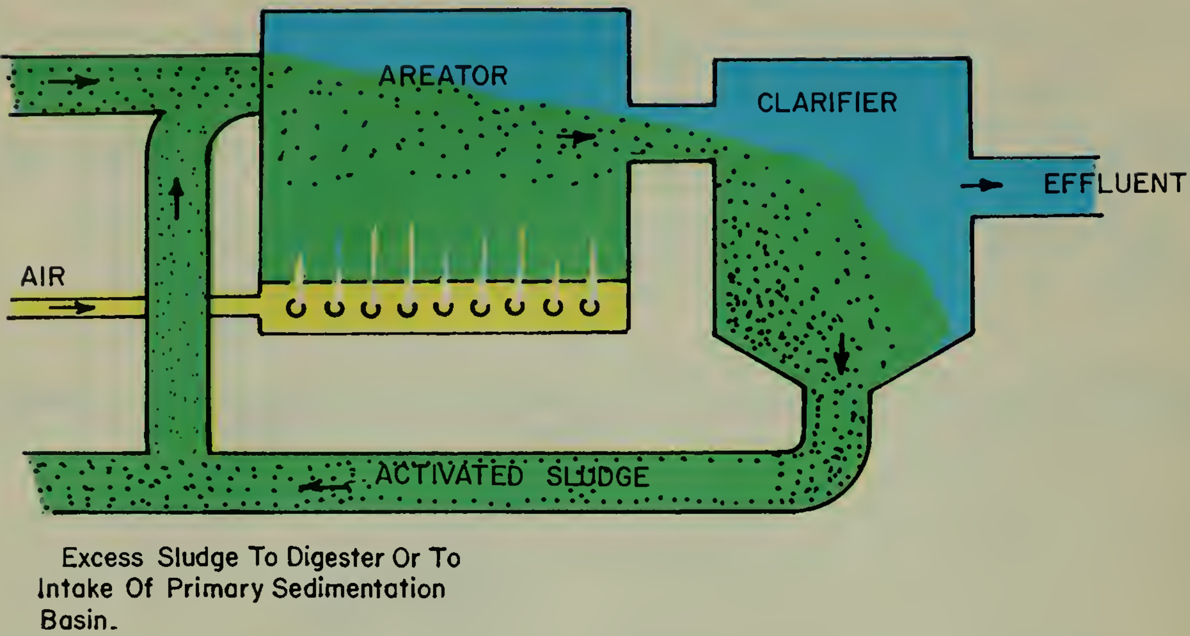


Figure 14. Activated Sludge Process

Oxidation ponds provide secondary waste water treatment by retention of primary effluent for upwards of 60 days, so that the bacteria and algae may have sufficient time to decompose and stabilize the organic material in the waste water. Two types of oxidation ponds are commonly used.

The first is an aerobic pond, in which oxygen, sunlight, and algae interact to decompose the organic waste material. The second type is the facultative pond, in which aerobic and anaerobic (without oxygen) processes take place simultaneously.

In the facultative pond, which is relatively deep, thermal stratification produces two layers of water. In the warmer upper layer, which is in contact with the atmosphere, aerobic decomposition takes place. In the lower layer, bacteria act to break down the waste material anaerobically, i.e., without the aid of oxygen, much as in a home septic tank. Effluents from oxidation ponds are often quite turbid, carrying a heavy concentration of algae.

Effluent that has received secondary treatment is usually disinfected with chlorine before reuse or discharge to receiving waters.

Advanced Treatment

Advanced treatment (Figure 15) may precede, accompany, follow, or replace primary and secondary treatment. When it follows secondary treatment, it is called tertiary. Advanced treatment removes or reduces specific constituents such as nutrients, suspended and colloidal organics, refractory or nonbiodegradable organics, dissolved inorganic minerals, and pathogenic organisms. Unlike the biological processes used for secondary treatment, most advanced treatment methods have been adapted from processes used for treatment of water supplies and industrial wastes.

Before most advanced waste treatment processes can be effective, most of the suspended and colloidal organic matter must be removed. This is most often accomplished by (1) chemical precipitation, using alum or lime as coagulants, (2) graded mixed-media, sand, or diatomaceous-earth filters, or (3) microscreens.

Removal of Nutrients. Special processes may be used to remove nitrogen and phosphorus, the primary nutrients that stimulate the growth of algae and other undesirable organisms. This is particularly important when reclaimed waste water is to be used for recreational lakes. Phosphorus can be removed by chemical precipitation, with lime as the coagulant.

A portion of the nitrogen (that existing as ammonia) can be removed by air stripping in a tower. In this process, lime is added to the water to convert the nitrogen to ammonia in the form of a dissolved gas. The water is then splashed over a series of slats; as the water strikes a slat, droplets are formed, and the ammonia gas escapes from the droplets. The escaping gas is then removed by air circulation. At the South Lake Tahoe reclamation plant, air enters the stripping tower through side louvers and travels horizontally to the center of the tower, where it is pulled upward by a fan.

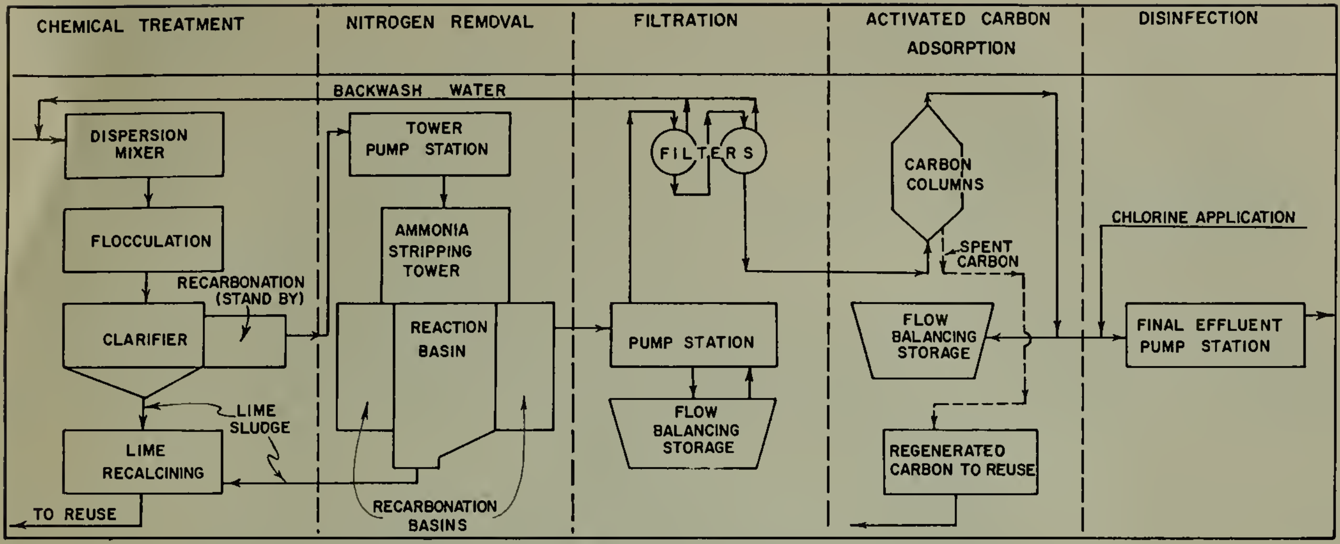
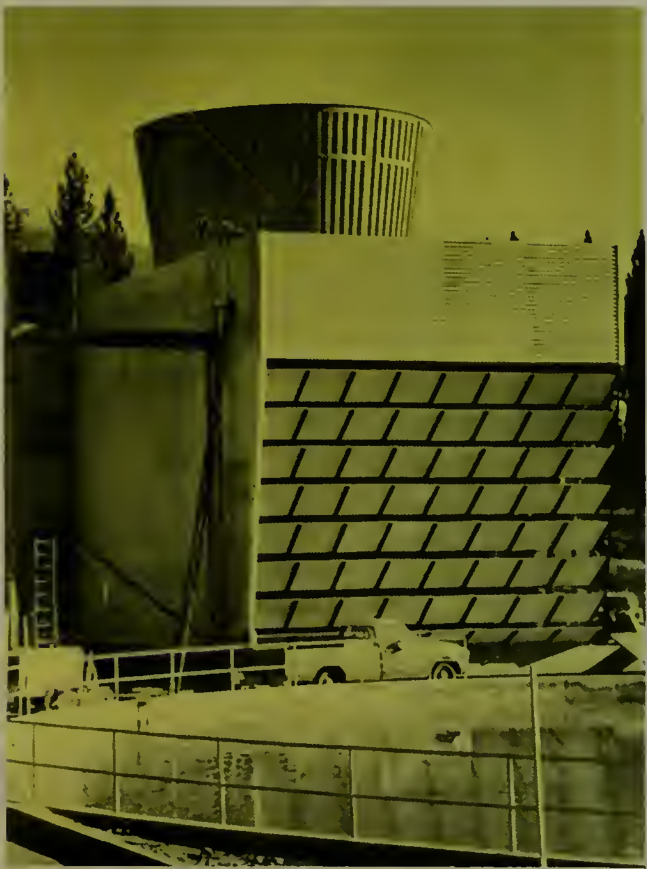


Figure 15. Typical Advanced Treatment Process, Schematic Diagram

Ammonia nitrogen can also be removed by columns of the selective zeolite ion exchanger, clinoptilolite. The ion exchanger is periodically regenerated with caustic and salt.



South Tahoe Public Utility District photo
Nitrogen Stripping Tower

Chemical precipitation and air stripping, combined with mixed media filters, are used at South Lake Tahoe to remove suspended and colloidal organics, phosphorus, and ammonia-nitrogen. At the South Lake Tahoe reclamation plant, nitrogen content is reduced some 30 to 98 percent, depending principally on temperatures. During cold weather, the air stripping process is considerably less efficient. Phosphorus content in the plant influent is reduced by more than 90 percent, and suspended and colloidal organics are almost completely removed.

If time is not important and land is not costly, nutrients can be removed in settling ponds. Over a period of time, algae will use nitrogen and phosphorus to grow additional algal cells. Removal of the algal cells reduces the nutrients in the remaining water. Unfortunately, this process is difficult to control and thus is generally inefficient.

Nitrogen can also be removed through a two-stage operation using nitrification and denitrification. In the first stage, bacteria are used to oxidize ammonia nitrogen to nitrates. In the second, or denitrification, stage, nitrates are converted to nitrogen gas. This stage requires the addition of a nitrogen-free organic substance (such as methanol) on which the bacteria can feed.

Refractory or nonbiodegradable organic substances can best be removed by passing the waste water through beds of granular activated carbon. Activated carbon will also effectively remove tastes and odors. In addition, the process will remove small quantities of nitrates by providing the anaerobic conditions necessary for denitrification, and it will also remove most suspended organic material remaining in the waste water. As an alternative to activated carbon, weak-

base synthetic resins have been specifically developed for the removal of soluble refractory organics.

The effluent is then disinfected with chlorine before it is discharged or made available for reuse.

Demineralization. When waste water contains excessive minerals (salts), or when its character may limit reuse, desalting processes may be used to remove dissolved salts.

Electrodialysis combines the use of an electrically charged cell and ion-selective membranes to remove salts from waste water. When a salt dissolves in water, it tends to break down into ions, or small groups of electrically charged atoms, each of which has either a positive charge (called cations) or a negative charge (called anions).

For example, the two parts of common table salt are the chemical elements sodium and chlorine. As salt dissolves in water, the sodium is present as positively charged sodium ions and the chlorine as negatively charged chloride ions.

As mineralized water is passed through an electrodialysis cell, the positively charged ions are drawn through a special membrane to a negative electrode, while the negatively charged ions are attracted through another membrane to a postitive electrode

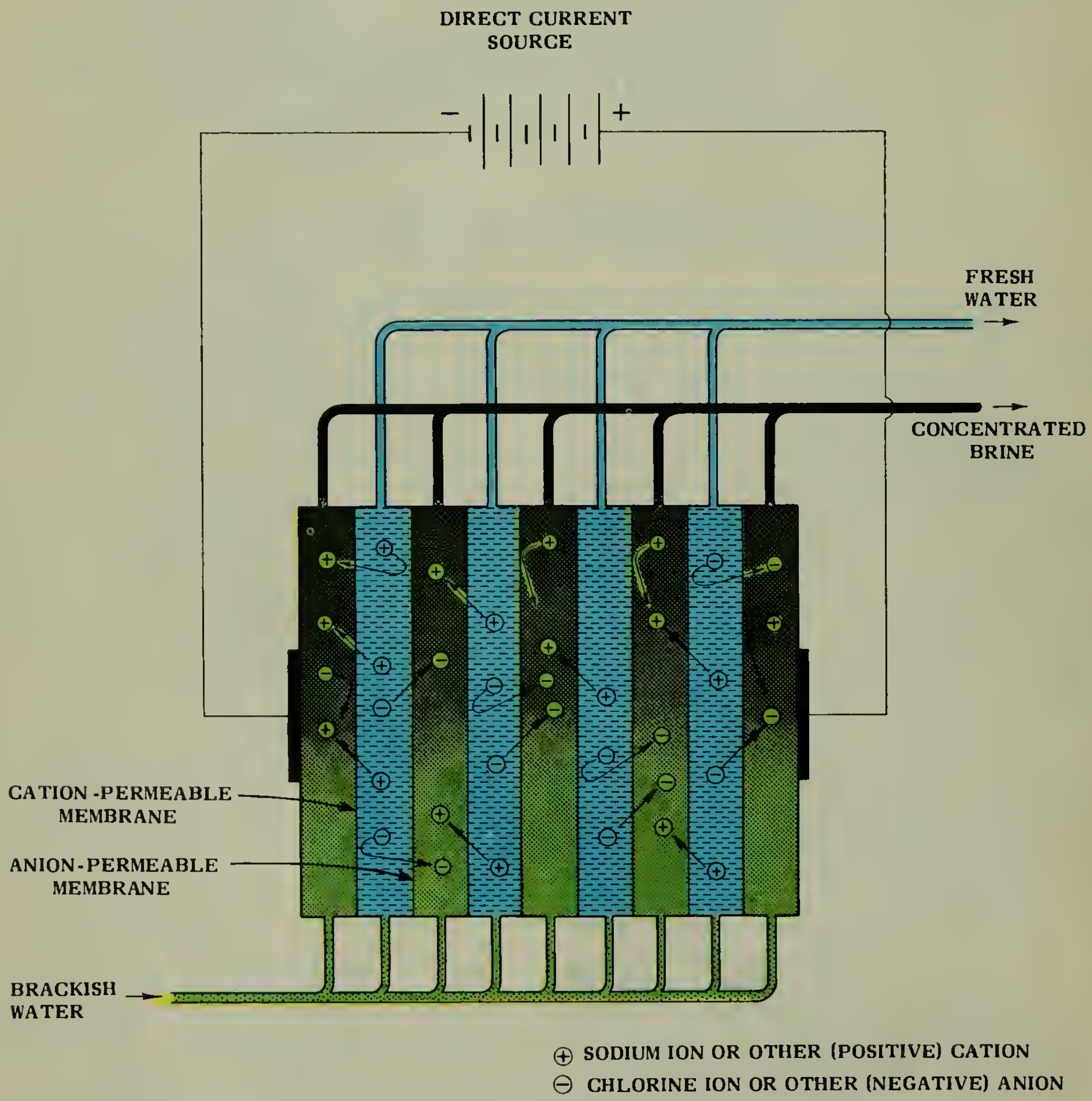


Figure 16. Principle of Electrodialysis

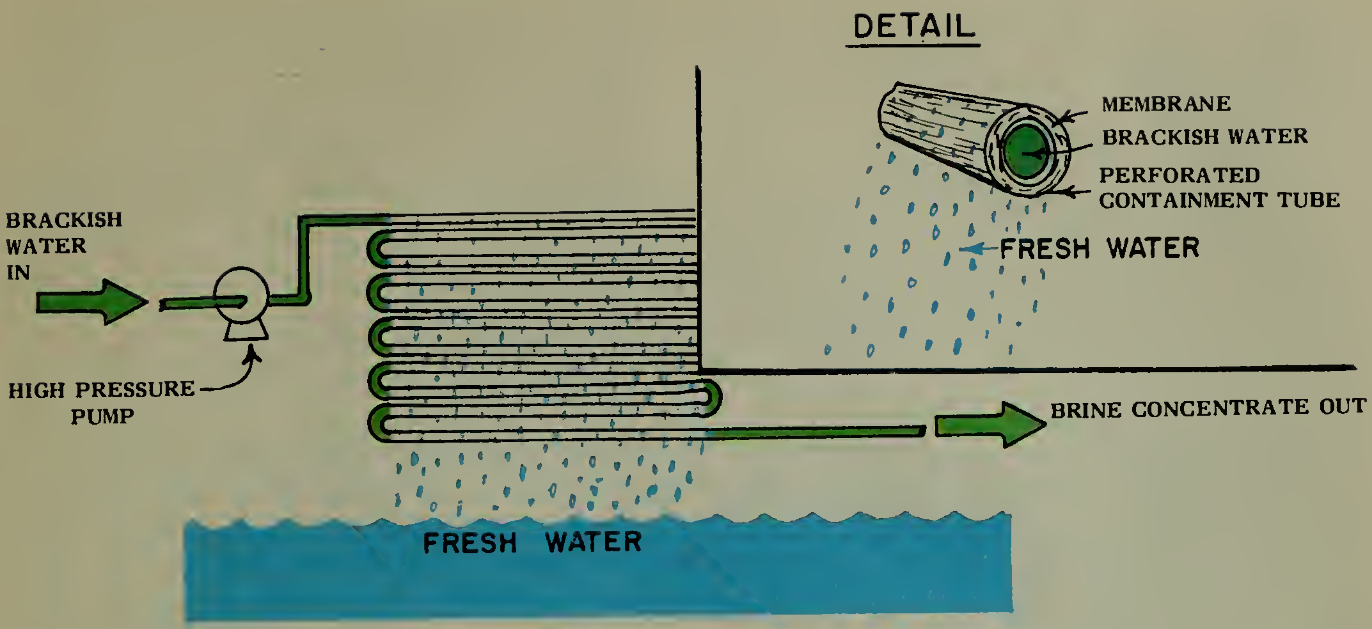


Figure 17. Principle of Reverse Osmosis—Tubular Type

(Figure 16). With the salt ions removed from the influent waste water, desalted water flows out of the cell for reuse.

In actual practice, a number of membranes can be placed between the electrodes, forming a number of dilute (demineralized) and concentrate (waste) compartments. Mineralized water is fed into the electrodialysis cell, and product water and waste concentrates are removed, through manifolds attached to the membrane stacks.

Electrodialysis is used at more than 100 water supply plants around the world, from small industrial plants to a plant in Sarasota County, Florida that treats 1.2 million gallons per day. Here, water with a dissolved solids content of 1,300 parts per million is desalted to a level of 500 parts per million.

Reverse osmosis is another demineralization process that may be used. Ordinarily, if fresh water and a salt solution are separated into compartments by a semipermeable membrane, the fresh water will pass through the membrane by osmotic pressure and dilute the salt solution. However, if pressure is exerted on the salt solution, the osmosis process can be reversed. When the pressure on the salt solution exceeds the natural osmotic pressure, fresh water from the salt solution will pass through the membrane in the opposite direction to the freshwater side, leaving the salts in a concentrated brine. Thus, instead of drawing pollutants from the water, reverse osmosis extracts water from the pollutants. The process will separate pure water from many waste waters, even those containing bacteria and detergents. Reverse osmosis is a most promising method, particularly for reducing salinity of brackish water. The principle of reverse osmosis is illustrated in Figure 17.

Ion exchange is still another demineralization process. An ion exchanger is a porous bed of natural material or synthetic resins that have the ability to exchange ions held in the resin with those in mineralized waste waters that contact the bed.

In the ion-exchange process, both cation (positively charged ions) and anion (negatively charged ions) exchangers are used. The ion-exchange beds are usually placed in series so that the saline waste water passes first through the cation exchanger and then through the anion exchanger.

In the cation exchanger, cations, such as sodium, are taken from the salt water, and a hydrogen ion is put into the water. In the anion exchanger, anions, such as chlorine, are taken from the water, and a hydroxide ion is put into the water. Thus, sodium chloride is removed from the waste water, leaving a demineralized effluent. In addition, the hydrogen ion and the hydroxide ion combine to form more water, thus adding to the volume of fresh water produced for reuse or disposal.

As the conversion process continues, the resins become progressively saturated until they finally lose their ability to remove the cations, such as sodium,

and the anions, such as chlorine. At this point, the resin beds must be regenerated with acid and caustic to restore their ion-exchange properties. These chemicals used to regenerate the resins also increase the waste requiring disposal.

Ion exchange, reverse osmosis, and electrodialysis are suitable processes for reducing the salinity of brackish waters. Energy requirements for electrodialysis and reverse osmosis are roughly proportional to the amount of minerals removed; i.e., the greater the degree of demineralization, the more energy required. In the ion exchange process, the amount of chemicals used for regeneration is proportional to the amount of salt removed from the waste water.

Distillation is still another method that could be used to reclaim waste water. In this process, the mineralized waters are converted to steam and condensed as mineral-free water. However, distillation is mainly used for desalting water with the highest salt concentrations, i.e., sea water, because electrodialysis, reverse osmosis, and ion exchange are less expensive processes for desalting ordinary backish water.

Variations of the distillation process are used to provide drinking water on ocean liners and in parts of the world where water supplies are limited. Of course, as in any desalting process, the minerals separated from the wastes remain behind and may pose a serious disposal problem.


South Tahoe Public Utility District photo
Carbon Adsorption Columns

Costs of Waste Water Treatment

Whether waste water is to be discharged or reclaimed, the costs of treatment vary considerably, depending, among other factors, on climate, size of plant, costs of construction, and quantity and character of the waste water. The estimated annual costs for a number of conventional treatment processes presented in Table 1 are based on typical costs at three different facilities capable of treating 1, 10, and 100 million gallons of waste water per day.

Table 1. Estimated 1972 Costs for Waste Water Treatment (per 1,000 gallons) [1]

Process	Size of facility		
	1 MGD[2]	10 MGD	100 MGD
Primary	$0.15–0.17	$0.07–0.09	$0.04–0.06
Primary with flocculation	0.18–0.20	0.10–0.12	0.07–0.09
Activated sludge[3]	0.24–0.27	0.14–0.16	0.07–0.10
Trickling filter[3]	0.21–0.23	0.10–0.13	0.06–0.08
Carbon adsorption[4]	0.22–0.24	0.10–0.12	0.04–0.06
Chemical coagulation and sedimentation[4]	0.05–0.06	0.04–0.06	0.04–0.05
Ammonia stripping[4]	0.04–0.05	0.02–0.03	0.01–0.02
Mixed media filtration[4]	0.10–0.11	0.04–0.05	0.02–0.03

[1] Includes capital amortization and the costs of normal operations and maintenance.
[2] 1 million gallons per day.
[3] Includes costs of primary treatment.
[4] Not including costs of any previous treatment.

The salt content of highly mineralized waste water must be reduced before the effluent would be suitable for reuse. As shown in Table 2, the costs of desalting mineralized wastes are significantly higher than those for conventional treatment.

Table 2. Estimated 1972 Costs of Desalting (per 1,000 gallons) [1]

Process	Size of facility		
	1 MGD	10 MGD	100 MGD
Reverse Osmosis (brackish water)	$0.42–0.45	$0.33–0.35	$0.30–0.35
Electrodialysis (brackish water)	0.52–0.60	0.35–0.40	0.30–0.35
Distillation (sea water)	1.35–1.50	1.00–1.25	0.75–1.00

[1] Cost at the plant boundary. Includes capital amortization and the costs of normal operation and maintenance.

Plans to reclaim waste water must include consideration of the location of the treatment plant and the need for distribution facilities. For example, treatment plants are frequently located at the lowest elevation of the collection system, adjoining a stream or river, an estuary, or the ocean. Therefore, pumping plants and pipelines are often required to transport the reclaimed water to the point of reuse. When additional facilities are necessary, the costs of construction, operation, and maintenance must also be considered.

The costs of transportation can vary widely. For instance, the irrigation of crops in fields adjoining a treatment plant in the San Joaquin Valley would probably require only short, inexpensive pipelines or small pumping lifts. However, when the effluent must be transported some distance and perhaps lifted over a mountain pass, as is the case at South Lake Tahoe, transportation costs become highly significant.

Treated effluent from the South Tahoe Reclamation plant is lifted 1,235 feet over the 7,735-foot Luther Pass and transported through a 27-mile-long pipeline to Indian Creek Reservoir in Alpine County. The cost of electric power to operate the pumps is about $120 per million gallons of transported effluent.

South Tahoe Public Utility District photo

Tertiary-treated effluent from South Tahoe Public Utility District reclamation plant, after a 27-mile journey through a pipeline over Luther Pass, forms beautiful Indian Creek Reservoir in Alpine County. In addition to fishing and pleasure boating, the reservoir provides irrigation water for lush Alpine County ranchlands.

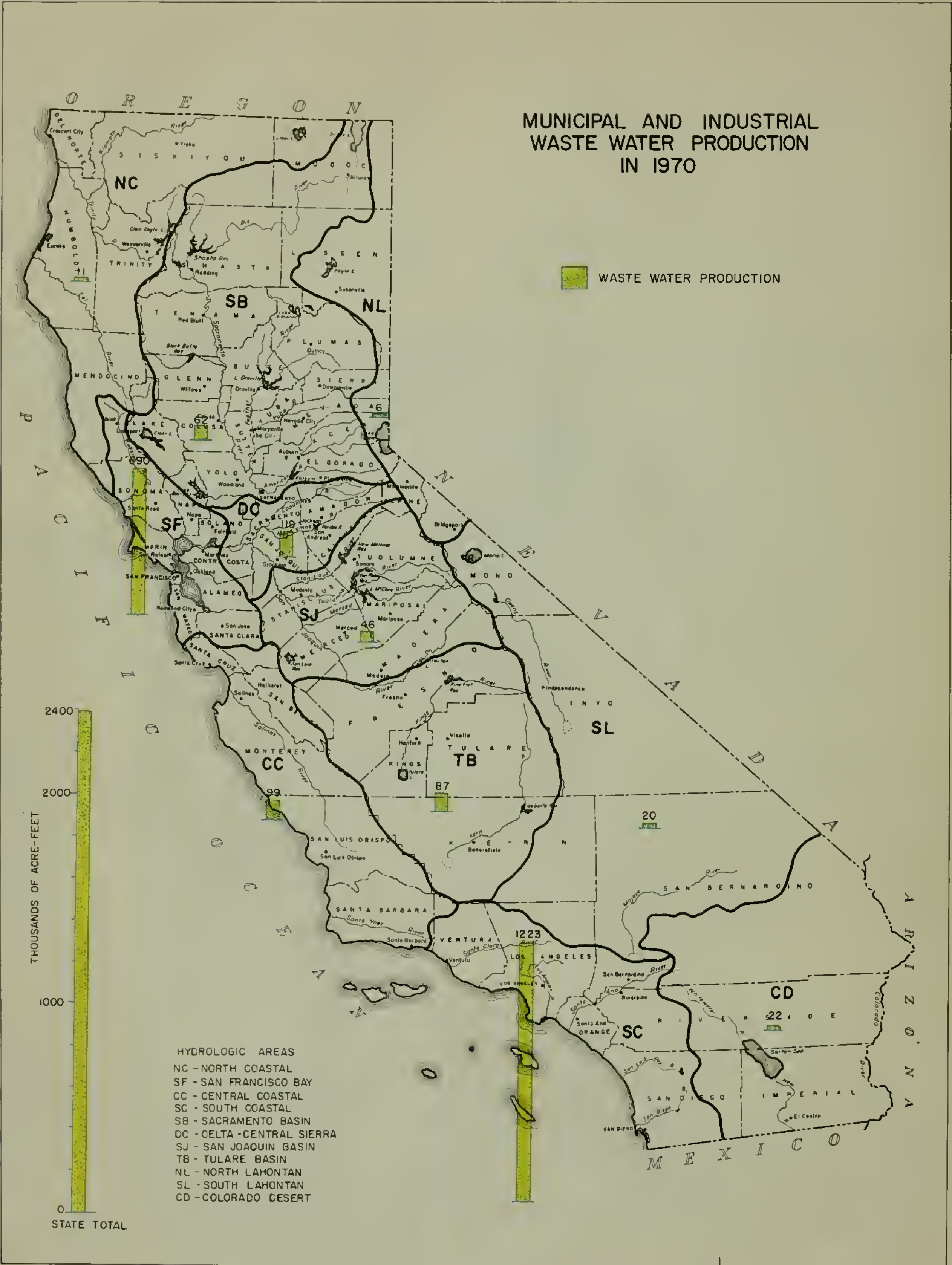


Figure 18. Municipal and Industrial Waste Water Production in 1970

IV. WASTE WATER RECLAMATION TODAY

About 2.4 million acre-feet of municipal and industrial waste water was produced in California during 1970 (Figure 18). Some 70 percent of this total contained fewer than 1,500 parts per million of dissolved solids and therefore was potentially reclaimable. However, during 1970, only about 175,000 acre-feet of this waste water was actually reclaimed. Figure 19 shows for each of the State's hydrologic areas, (1) the quantity of waste water reclaimed in each area, and (2) the percentage of the total quantity reclaimed in California.

An estimated 25,000 acre-feet of the total reclaimed represents a "new" water supply; that is, had this amount not been reclaimed, it would have been discharged to saline waters and lost to the usable fresh water supply. The remaining 150,000 acre-feet would have been available for incidental reuse through disposal to land or to streams.*

When compared with the total waste water produced in 1970, the amount reclaimed is small. However, in many parts of the State, the costs of collecting and treating waste water, and of distributing reclaimed water, exceed the cost of alternative fresh water supplies. In addition, most users prefer less mineralized water. Finally, some of these waste waters may have contained excessive toxic substances, e.g., arsenic, mercury, cadmium, chromium, etc., and therefore would have been unsuitable for reclamation.

* See Chapter II, page 12.

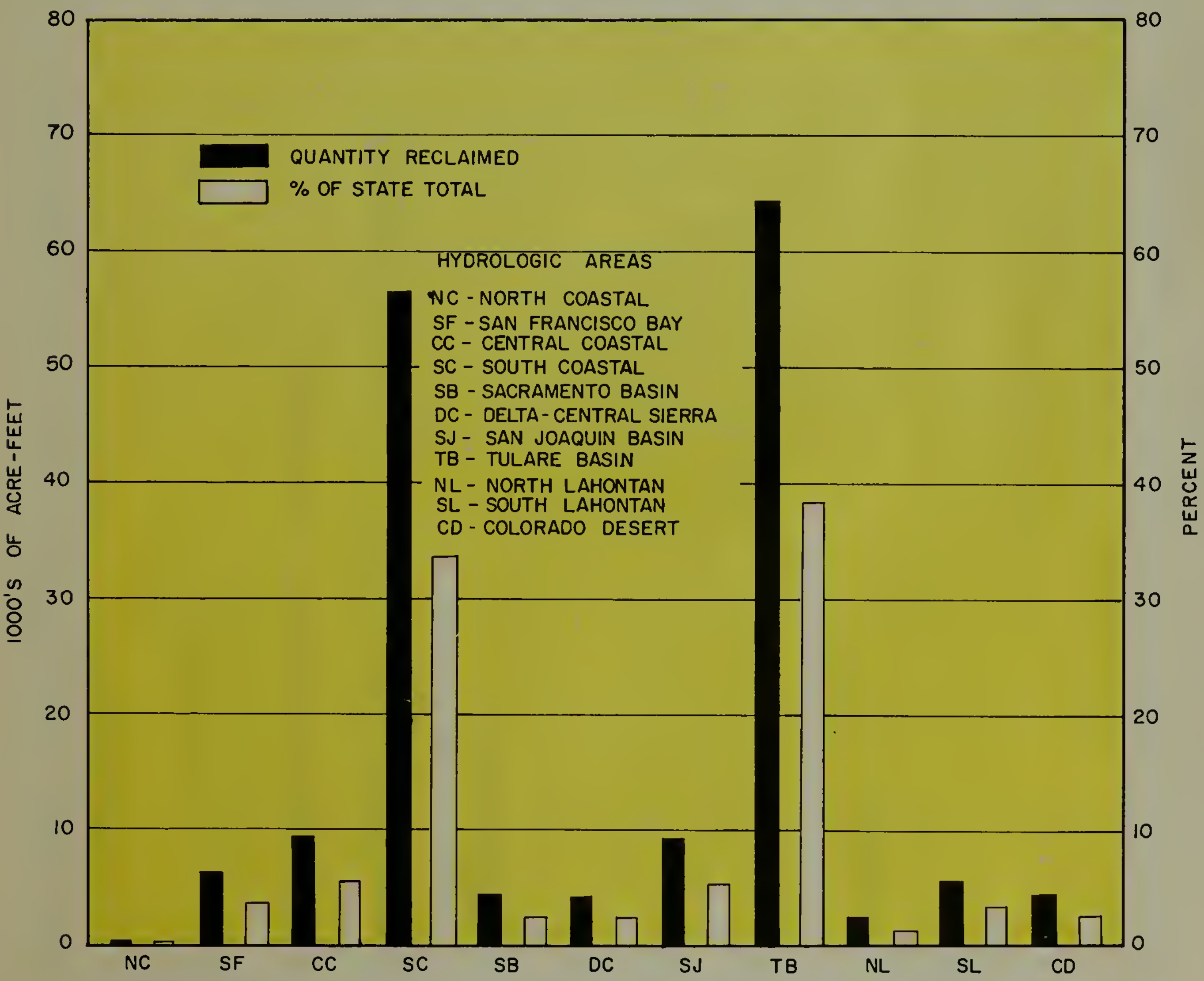


Figure 19. Municipal and Industrial Waste Water Reclamation by Hydrologic Area, 1970

Of the 175,000 acre-feet actually reclaimed during 1970:

- 77 percent was used for the irrigation of field crops, fodder, orchards, fiber, seed, other non-food crops, and improved pasture.
- 8 percent was used to irrigate golf courses and athletic fields.
- 7 percent was used for landscape irrigation in parks, cemeteries, freeway rights-of-way, and grounds of public institutions.
- 4 percent was devoted to such municipal uses as cooling water at waste-water treatment plants, landscape irrigation, and fire protection.
- 2 percent was used for such recreational pursuits as boating, fishing, swimming, etc.
- the remaining 2 percent was used for industrial cooling and processing water.

As shown in Figure 19, more than 70 percent of the 1970 State total was reclaimed in the Tulare and South Coastal Basins. The relatively high rate of reuse in the Tulare Basin, where natural water supplies are scarce, resulted from the need for reclaimed water for the irrigation of crops. Figure 20 shows the proportion reclaimed of the municipal and industrial waste water produced in each hydrologic area during 1970. As shown in Figure 20, almost 75 percent of the municipal and industrial waste water produced in the Tulare Basin during 1970 was reclaimed.

In the South Coastal Basin, the scarcity of natural water supplies, the high cost of imported water, and

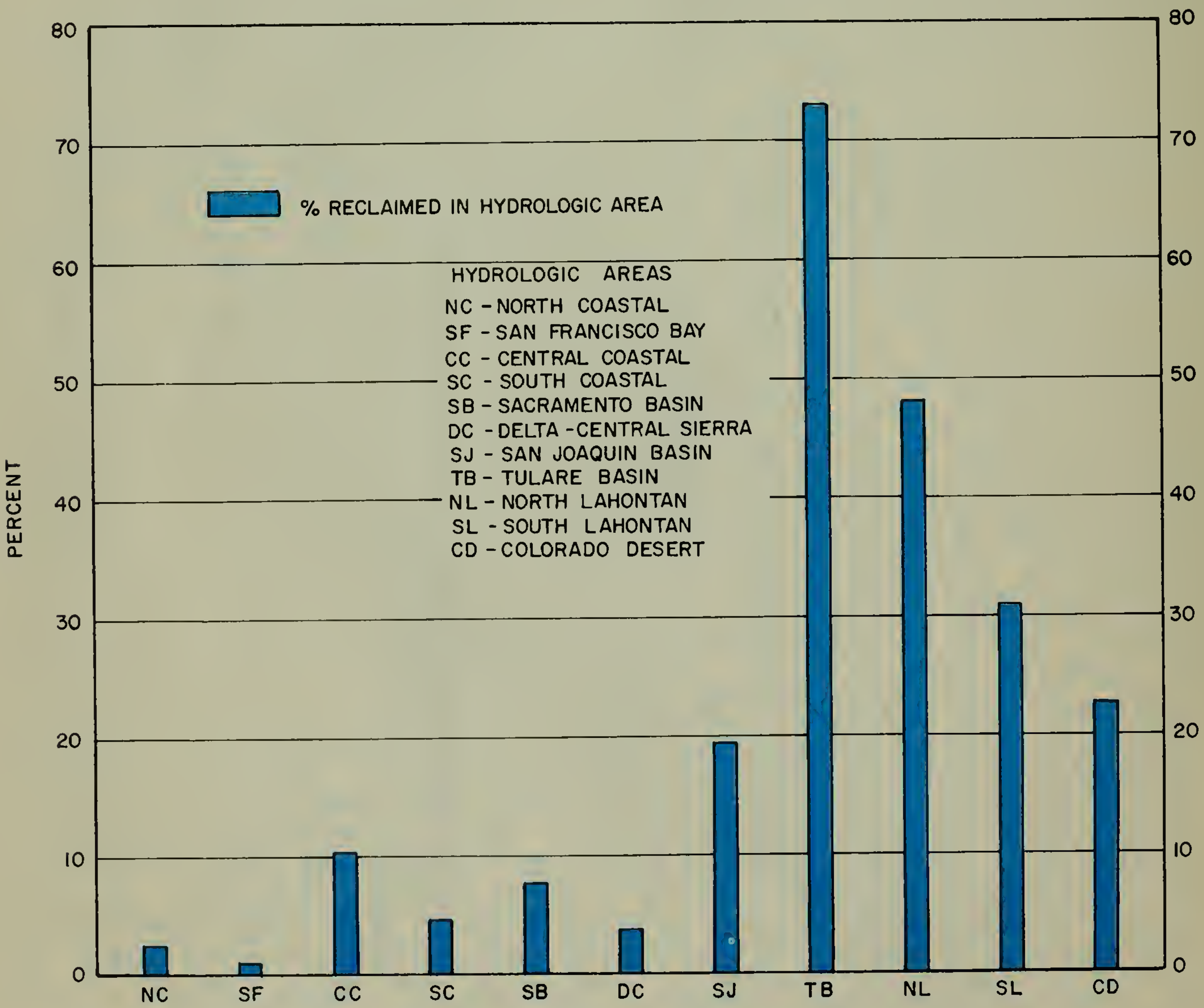


Figure 20. Proportion Reclaimed of Municipal and Industrial Waste Water Produced in each Hydrologic Area, 1970

magnitude of waste water production account for the increasing reclamation practiced there. Still, only about 5 percent of the waste water produced in the South Coastal Basin during 1970 was reclaimed. This was because of the high mineral content of much of the waste water and the cost of reclamation and distribution of large quantities at coastal treatment sites, which have made reclamation relatively unattractive in the South Coastal Basin.

Entities Reclaiming Waste Water in California

About 90 percent of the water reclaimed during 1970 was treated in facilities operated by local governments (cities, counties, districts, and the State), 8 percent in federal installations, and 2 percent in private systems. Thirteen facilities treating 5 million gallons or more of waste water per day (only local governments have facilities this large) accounted for 30 percent of this reclaimed waste water; 55 facilities treating 1 to 5 million gallons per day accounted for 52 percent; and the remaining 18 percent was reclaimed by 136 facilities treating less than 1 million gallons per day.

During 1970, 830 systems were operated to treat waste water for either reuse or disposal. Of this total, 204 reclaimed waste water for planned uses. For convenience, these waste treatment systems will be discussed as:

1. Large facilities—those treating 5 million gallons, or more, per day;
2. Medium-size facilities—those treating 1 to 5 million gallons per day; and
3. Small facilities—those treating less than 1 million gallons per day.

Large Facilities

During 1970, 48 large treatment facilities treated 1.8 million acre-feet of waste water. Almost 55,000 acre-feet of water was reclaimed by 13 of these 48, in which a total of 670,000 acre-feet of waste water was treated. Four facilities, described briefly in the following table, accounted for about 25 percent of the waste water reclaimed in California during 1970.

One of the most innovative of these large facilities is the Whittier Narrows plant of the County Sanitation Districts of Los Angeles County. Here, waste water receives primary and secondary treatment and is used for ground water recharge by percolation into the bed of the San Gabriel River. The plant, which began operation in 1962, was originally designed to treat 10 million gallons per day, but the daily capacity has since been expanded to 15 million gallons. The Sanitation Districts are now planning to develop a similar facility at another location in Los Angeles County.

Location	Water treated (acre-feet/year)	Water reclaimed (acre-feet/year)	Use
City of Fresno	17,400	15,400	Irrigation of 3,500 acres of corn, grain, alfalfa, and grasses for cattle feed
Whittier Narrows, Los Angeles County	17,100	14,700	Ground water recharge
City of Bakersfield	14,100	13,800	Irrigation of cotton, alfalfa, grasses, pasture, and potatoes
City of Burbank	6,200	1,500	Powerplant cooling

Medium-Size Facilities

During 1970, 158 medium-size plants treated 380,000 acre-feet of waste water. Of these, 55 facilities reclaimed 88,200 acre-feet. At 42 of these latter plants, at least 25 percent of the treated waste water was reused.

Several innovative uses of water reclaimed at three medium-sized facilities are presented in the following paragraphs. Data on a number of other medium-size plants are also presented.

City and County of San Francisco—Golden Gate Park. In 1889, John McClaren, Superintendent of Golden Gate Park, began irrigating park lands with untreated sewage. However, because of complaints, a septic tank was installed in 1912. Effluent from the septic tank was used to fill and maintain a series of ornamental lakes and for the irrigation of about 250 acres.

The existing reclamation plant, which began operation in 1932, is the first plant constructed in California solely for waste water reclamation. Reclaimed water from this secondary-treatment plant was first used to fill the park ornamental lakes.

The use of reclaimed water was later expanded to include irrigation of the polo field and other areas within the park. Because the limited use of treated water for irrigation after 1932 evoked no complaints, reuse of the water was later expanded to the entire park irrigation system. Today, this source supplies about 25 percent of the park's total water needs for horticultural irrigation. During 1970, the plant provided 1,100 acre-feet of reclaimed waste water.

Santee County Water District. In 1961, the Santee County Water District in San Diego County began treating raw sewage in a modified activated-sludge plant, with 30-day ponding and percolation through

Stowe Lake, Golden Gate Park, San Francisco

400 feet of sand and gravel and subsequent reuse for recreational lakes and irrigation of a golf course. In 1968, the original plant was replaced with an automated facility designed to treat 4 million gallons of domestic sewage per day.

Raw sewage is pumped into the plant, where it undergoes activated-sludge treatment. After chlorination, the effluent flows into an oxidation pond, where it is retained for 10 days.

After a second chlorination, the treated effluent is discharged for percolation underground. The percolating treated water travels about one-half mile to collection galleries, from which it is diverted to six lakes.

Sailing at Santee

Four of these lakes are used for boating and fishing. Water from the lakes is also used to irrigate a park, and some of the reclaimed water is used to irrigate a nearby golf course.

South Tahoe Public Utility District. All waste waters in the Tahoe Basin must be treated and exported. The reclamation plant of the South Tahoe Public Utility District near Lake Tahoe provides tertiary treatment for removal of nutrients and nonbiodegradable organics.

The treatment facilities, designed to treat 7.5 million gallons of waste water per day, consists of primary treatment, the activated sludge process, chemical precipitation for phosphate removal and clarification, am-

Prize Catch at Indian Creek Reservoir

monia stripping towers, filtration through mixed-media filters, removal of nonbiodegradable organic material through carbon adsorption columns, and chlorination prior to disposal.

Water reclaimed at the South Tahoe treatment plant is pumped through a 27-mile-long pipeline to Indian Creek Reservoir in Alpine County. The reservoir has a surface area of 163 acres and a maximum storage capacity of 3,225 acre-feet. In 1970, the project provided 2,500 acre-feet of reclaimed water for recreation, such as boating, fishing, water skiing, picnicking, and swimming. Water from the reservoir is also used for the irrigation of Alpine County ranches.

The quality of the original water supply in the Tahoe Basin is excellent, and the treatment plant produces an effluent that meets the stringent requirements

of the California Water Quality Control Board, Lahontan Region. Yet, even with advanced treatment, not all the nitrates and phosphates, which are nutrients that support plant growth, are removed.

Other Medium-Size Facilities. A number of other medium-size waste water reclamation systems provide water for various purposes. These are shown (for 1970) in Table 3.

Four examples of reclamation by such smaller facilities follow:

County Sanitation Districts of Los Angeles County (Azusa, La Canada, and Lucky Lager Facilities). These three reclamation facilities provide 1,400 acre-feet of reclaimed water for ground water recharge.

Moulton-Niguel Water District. This water district has three reclamation plants that provide about 1,300 acre-feet of reclaimed water for landscape irrigation.

Table 3. Use of Reclaimed Water by Medium-Size Facilities (1970)

System or facility	Water treated (acre-feet)	Water reclaimed (acre-feet)	Used for
City of San Clemente	2,000	1,700	Golf course irrigation
Camp Pendleton Marine Base	4,300	4,300	Golf course irrigation
China Lake Naval Air Station	1,900	600	Golf course irrigation
Fort Ord (U. S. Army)	2,600	2,200	Golf course irrigation
George Air Force Base	1,100	400	Golf course irrigation
El Toro Marine Air Base	1,100	600	Golf course irrigation
Twenty-Nine Palms Marine Base	1,300	900	Golf course irrigation
Rossmoor Sanitation, Inc. (Laguna Hills)	1,500	1,200	Golf course irrigation
City of Gustine	3,700	3,700	Wildlife refuges
Eastern Municipal Water District (Hemet)	1,800	1,800	Ground water recharge
City of Redlands	2,400	2,400	Ground water recharge
City of Oceanside	3,300	2,200	Ground water recharge
Kaiser Steel Corp. (Eagle Mountain Facility)	1,800	700	Cooling and process
Other facilities (combined total)	96,500	59,500	Crop irrigation

Small Treatment Facilities

The majority of waste water reclamation plants treat fewer than one million gallons per day, and these smaller facilities provide nearly one-fifth of the water reclaimed in California. During 1970, 571 small installations collectively treated 146,000 acre-feet of waste water, and provided almost 33,000 acre-feet of reclaimed water for such uses as landscape irrigation, crop irrigation, golf course irrigation, various industrial processes, and ground water recharge.

Kaiser Steel Corporation, Fontana Plant. The reclamation of waste water at the Kaiser Steel Fontana plant provides cooling and process water. During 1970, the Kaiser facility reused about 800 acre-feet.

North American Rockwell Corporation, Canoga Park. The North American Rockwell Corporation reuses some 200 acre-feet of reclaimed water for cooling and fire control at a rocket test site.

County Sanitation Districts of L.A. County photo

San Jose Creek Water Renovation Plant, County Sanitation Districts of Los Angeles County, treats 30 million gallons per day of waste water from Azusa, West Covina, Pomona, and other communities in northeast Los Angeles County.

V. FUTURE OPPORTUNITIES FOR RECLAMATION

Although the rapid rate of population growth that followed World War II had decreased sharply by the mid-1960s, recent population projections indicate that the current California population (20 million in 1970) will increase to about 29 million in 1990 and to 43 million in 2020.* This growth in population will be accompanied by a related growth in the demand for water for all uses.

Net water demands are expected to increase from the present 28.6 million acre-feet to 34.5 million acre-feet in 1990 and 39.8 million acre-feet in 2020. Almost 50 percent of the increase predicted for 1990, and more than 70 percent of that predicted for the period between 1990 and 2020, can be attributed to the anticipated growth in municipal and industrial water demands.*

When treated water is reclaimed, instead of being discharged to saline or brackish waters, the water thus reclaimed becomes a new source of water supply. Accordingly, reclaimed waste is a potential source of supplemental water supplies and could meet at least a part of the growing demands, although its use would not entirely eliminate the need for additional supplies of water from other sources.

Of course, in most inland areas today, treated waste water is often discharged to good-quality surface and ground water. In such cases, these waste waters remain in the usable water cycle and are thus "recycled" but do not create a "new" water supply.

Indeed, much of the water used in California is returned to the freshwater cycle either directly after its use or following treatment. This includes most of the irrigation-return waters from 8.5 million acres of irrigated land in California, and the treated wastes from cities, where waste water returns to and mingles with freshwater supplies for further use. Although reclamation of these waters would tend to enhance water quality, it would not create a "new" water supply.

Only when waste waters would otherwise be discharged to saline water, or have been so degraded that they cannot be discharged to fresh water, does their reclamation create a "new" supply. In California, these possible new sources of water include (1) municipal and industrial wastes discharged to the ocean, saline bays, and estuaries; and (2) agricultural waste water in the San Joaquin Valley that has become so saline that it must be collected and removed from the freshwater cycle.

* These population predictions and the forecasts of future water demands are based on those provided in Department of Water Resources Bulletin No. 160-70, "Water for California, The California Water Plan, Outlook in 1970", Summary Report. December 1970.

As pointed out in Chapter I, the amount of waste water that can be reclaimed is limited. Up to 50 percent of a given municipal water supply is used consumptively and is therefore unavailable for reclamation. Another 20 to 30 percent of the water originally supplied is needed to both carry off concentrated wastes and prevent the accumulation of salts. Accordingly, only about 20 to 30 percent of the original supply remains for possible reclamation, even if the waste water is desalted.

The reclamation of water from wastes will be most productive when:

- Water is costly or scarce.
- Wastes are discharged to saline or brackish waters and are thus lost to further beneficial use.
- Waste discharge requirements are necessarily restrictive, or discharges are banned, and export of wastes is needed to maintain water quality.
- The quality of the initial water supply is sufficiently good that after only one cycle of municipal use, the waste water can generally be treated by conventional processes and reclaimed without demineralization.
- People approve of and are willing to support reclamation projects.

California Basins With High Potential For Reclamation

Five basins that appear to offer especially favorable conditions for reclamation and reuse of waste water include:

1. The nine-county San Francisco Bay area.
2. The Central Coastal Basin, from the Monterey Bay area in the north to the Santa Barbara-Ventura area in the south.
3. The South Coastal Basin, covering the metropolitan areas of Los Angeles, Orange County, and San Diego.
4. The San Joaquin Basin, which includes the entire drainage area of the San Joaquin River in the counties of Madera, Merced, Mariposa, Stanislaus, Tuolumne, and the southern portion of San Joaquin County.
5. The Tulare Lake Basin, including Fresno, Kings, and Tulare Counties, and those portions of Kern and San Benito Counties lying in the Central Valley.

These areas are considered particularly suitable for reclamation and reuse of waste water because of (1) present and projected supplemental water demands, (2) salinity of much of the basic water supplies, or (3) costs of alternative supplemental supplies. Projected supplemental water demands (demands in excess of the capabilities of existing and authorized facilities) expected to develop in each of these five basins by the end of the next 50 years are as follows:

Basin	*Projected Supplemental Demands (1,000 acre-feet)*
San Francisco Bay	470
Central Coastal	360
South Coastal	650
San Joaquin	610
Tulare Lake	2,090

Municipal and Industrial Waste Water

In the three large coastal metropolitan areas, i.e., San Francisco Bay, Los Angeles Metropolitan, and San Diego Metropolitan, reclamation of waste water offers particular potential as an alternative water supply. These basins depend to some extent now, and will depend to a greater extent in the future, on good quality water imports, and much of the waste water produced in these basins is of reusable quality.

Table 4 provides projections by urban area of (1) total municipal and industrial waste production, and (2) the amount of discharged wastes that, considering present and planned water supplies, would be chemically suitable for reclamation. Much of the waste water from these areas, if reclaimed, would represent a "new" water supply in lieu of discharge to saline waters. The amount of water that may be reclaimed in each area will depend on various factors, including costs, suitability of the water for various uses, and marketing factors.

Table 4. Municipal and Industrial Waste Water Production in Coastal Metropolitan Areas (1,000 acre-feet)

Area	Total waste produced			Suitable for reclamation		
	1970	1990	2000	1970	1990	2000
San Francisco Bay	607	1,140	1,360	560	950	1,140
Monterey Bay	50	140	180	50	140	180
Santa Barbara-Ventura	70	230	340	60	190	290
Los Angeles Metropolitan	1,070	1,730	2,160	890	1,450	1,800
San Diego Metropolitan	110	260	390	80	200	300


County Sanitation Districts of L.A. County photo

Pomona Research Facility, operated jointly by the County Sanitation Districts of Los Angeles County and the Federal Environmental Protection Agency. The facility conducts research in advanced treatment processes, such as the removal of mineral, nutrient, and residual organics.

Agricultural Waste Water

Both the San Joaquin and Tulare Lake Basins offer potential for reclamation of agricultural waste water. Recent estimates indicate that, at the 1970 level of development, some 87,000 acre-feet of agricultural waste waters were generated each year in these two basins. This is expected to increase to 400,000 acre-feet by 1990.

Some means of disposal or reclamation of these waste waters is fast becoming a necessity. In the San Joaquin Basin, the U. S. Bureau of Reclamation is constructing the first phase of the San Luis Drain to remove agricultural wastes from the San Luis Project service area.

At the present time, the average salt concentration of these agricultural waste waters is about 6,800 parts per million. This, of course, exceeds the maximum practicable limit for reclaimable water. However, as salts are leached from the soil, the average mineral concentration is expected to decline to about 3,000 parts per million by the year 2000.

Two possible alternatives exist for the use of these highly saline waste waters:

1. They could be desalted to provide additional local water supplies.
2. They could be softened and used for powerplant cooling.

In Conclusion

By 1990, an estimated 4.2 million acre-feet of municipal and industrial waste water may be produced in California, most of it in the major coastal metropolitan areas. Perhaps 2.5 million acre-feet of this waste water may be reclaimable. However, because of the high costs of treatment and conveyance to areas of use, public attitudes on the use of reclaimed water, and the availability of alternative water supplies, reclamation projects will probably provide only about one million acre-feet of "new" water in California by 1990. If, as expected, our net water use increases to some 35 million acre-feet in that same year, reclaimed water would then provide about three percent of California's water needs.

The costs of reclaimed water vary widely, depending on the quantity and quality of the waste water, disposal requirements, and the intended use. Present costs range from:

- Two to five dollars per acre-foot in areas where reclaimed water can be used for irrigation near a treatment plant.
- Twenty to forty dollars per acre-foot where extensive treatment, storage, transportation and disposal are required.
- More than $100 per acre-foot where more extensive treatment, such as desalting, is required.

Although reclaimed water is not a panacea for California's water problems, it is fast becoming an important feature in the management of our water resources. Reclaimed water can help meet our water needs, help improve our water quality, and help enhance our environment.

However, if we are to enjoy the benefits offered by large-scale waste water reclamation, we must be willing to use reclaimed water and to invest in the required facilities.

ADDENDA

1. Publications (1950–1972) and current activities of the Department of Water Resources
2. Glossary of terms
3. California Water Reclamation Law

PUBLICATIONS (1950–1972) AND CURRENT ACTIVITIES OF THE DEPARTMENT OF WATER RESOURCES

Reclamation activities by the Department of Water Resources between 1950 and 1972 have been recorded in five statewide inventory bulletins and in three office reports:

1. "First Progress Report on Reclamation of Water from Sewage or Industrial Waste", December 1950.

2. "Second Progress Report on Reclamation of Water from Sewage or Industrial Waste", June 1954.

3. Bulletin No. 68, "Reclamation of Water from Sewage and Industrial Waste in California, July 1, 1953 to June 30, 1955", January 1958.

4. Bulletin No. 68-62, "Reclamation of Water from Sewage and Industrial Waste in California, July 1, 1953 to June 30, 1962", October 1963.

5. "Quantity, Quality and Use of Waste Water in Southern California, July 1, 1962 to June 30, 1963", December 1965.

6. "Quantity, Quality and Use of Waste Water in Southern California, July 1, 1964 to June 30, 1965", January 1967.

7. "Quality and Use of Waste Water, 1962 to 1965", July 1966.

8. Bulletin No. 68-71, "Inventory of Waste Water Production and Waste Water Reclamation Practices in California, 1970–71", November 1972.

Since 1965, the Department has published data on waste water production in both the Central Coastal area and Southern California as Appendix F to the annual bulletins reporting hydrologic data for these two areas:

1. Bulletin No. 130-67 (-68, -69, and -70) "Hydrologic Data: 1967; Volume III: Central Coastal Area".

2. Bulletin No. 130-67 (-68, -69, and -70) "Hydrologic Data: 1967; Volume V: Southern California".

The Department has also prepared overview reports on waste water reclamation:

1. Bulletin No. 80, "Feasibility of Reclamation of Water from Waste: Los Angeles Metropolitan Area", December 1961.

2. Bulletin No. 80-2, "Reclamation of Water from Waste: Coastal San Diego County", February 1968.

3. Bulletin No. 80-3, "Reclamation of Water from Waste: Coachella Valley", December 1966.

4. "Reclamation of Water from Waste: Ventura County", December 1969.

Two other Department reports cover specific projects:

1. "Feasibility of Reclamation and Conveyance of Sewage from San Francisco Peninsula Cities and Communities and San Jose for use in Santa Clara County". April 1951.

2. Bulletin No. 67, "Reclamation of Water from Sewage and Industrial Waste, Watsonville Area, Santa Cruz and Monterey Counties", August 1959.

The Department is presently conducting overview studies in the Monterey Bay tributary basin, the Sacramento River basin, the San Francisco Bay area, Southern California, and the Tulare Lake basin.

The Department is also conducting three specific feasibility investigations:

1. Feasibility of reclaiming water from municipal waste water for cooling thermal powerplants.

2. Feasibility of reclaiming water from agricultural waste water for cooling thermal powerplants in the San Joaquin Valley.

3. Feasibility of ground water recharge as a market for reclaimed water in the South Coastal area.

Other specific studies scheduled for 1972–73 include:

1. An interagency project to augment Sacramento-San Joaquin Delta outflows with reclaimed water from San Francisco Bay communities.

2. A project using reclaimed water for fire suppression in Los Angeles and San Diego.

3. A waste water reclamation project using municipal wastes in Sacramento County.

GLOSSARY OF TERMS

Activated sludge process is a treatment process that removes (by biological assimilation and decomposition) organic matter from waste water using a biologic floc in an aerobic environment.

Adsorption is a process for removing objectionable organic matter associated most often with taste and odors. Columns of activated carbon appear most promising.

Advanced treatment processes remove or reduce nutrients, dissolved solids, suspended or colloidal solids, toxic matter, and other constituents, using any physical, chemical, or biological process. Advanced treatment has come to mean any process added to the traditional primary-secondary treatment plant or to recently developed innovative processes not characteristic of recent practice.

Aeration tank is a chamber in which air is injected into waste water.

Algae are microscopic plants that grow in sunlit water that contains phosphates, nitrates, and other nutrients. Algae are food for small aquatic animals and, like all plants, add oxygen to the water. They are important in the fish-food chain in some instances.

Anion is a negatively charged ion.

Bacteria are microscopic unicellular organisms which consume organic constituents in waste water.

Biodegradable substances are those that will decompose, or break down, by biological treatment processes.

BOD (Biochemical oxygen demand) is the dissolved oxygen required by organisms for the aerobic decomposition of organic matter in a standard laboratory test.

Cation is a positively charged ion.

Chlorinator is a device for adding chlorine gas to waste water to kill pathogenic organisms.

Clarifiers are sedimentation tanks used to remove settleable solids in waste water treatment. They are used to partially clarify raw sewage following biological treatment.

Coagulation is the clumping together of solids to force them to settle out of waste water more quickly. Coagulation of solids is brought about through the use of certain chemicals, e.g., lime, alum, and iron salts. Coagulation is also brought about in biological treatment.

Combined sewer carries both waste water and storm water.

Comminutor is a device for shredding heavy solid matter in the pretreatment stage of waste treatment.

Controlled reuse is the use of reclaimed water under legal and physical control or restraint.

Degrees of treatment refer to the reduction and removal of undesirable constituents in waste water. In general, the degrees are termed primary, secondary, and advanced.

Diamotaceous earth is a light, chalklike siliceous material which is used as a filter aid in some water treatment plants. It may have applications in waste water treatment.

Diffused air is air under pressure, forced into waste water in an aeration tank. The air is pumped down into the waste water through a pipe and escapes through holes in the sides of the pipe or diffusers.

Digestion of sludge is a process which takes place in closed tanks where the organic materials decompose to form gases and a humus-like material that is periodically drained from the tank and dried for subsequent disposal.

Direct reuse is use of reclaimed waste water directly from a reclamation facility without passing through a natural body of either surface or ground water.

Disinfection is the destruction of most disease causing (i.e., infectious) organisms, as contrasted with sterilization, which is the destruction of all living organisms.

Distillation consists of heating the waste water to vapor or steam. When the steam is condensed to a liquid, it is almost pure water.

Effluent is the liquid product of a treatment unit, plant, or facility.

Electrodialysis is a process which separates soluble minerals from brackish water using an arrangement of anion- and cation-permeable membranes in a cell, across which an electric potential is applied.

Facultative means capable of life under more than one set of conditions, as aerobic or anaerobic (meaning with or without oxygen).

Floc is a clump of solids formed in waste water through biological, physical, or chemical action.

Flocculation is a process by which clumps of suspended solids in waste water are formed and enlarged by chemical, physical, or biological action to facilitate their settling.

Flotation is the process by which substances immersed in liquid rise to the surface by virtue of either differences in specific gravity or the buoyancy produced by the evolution of gas from chemicals, heat, or aeration.

Fungi are nonchlorophyll-bearing plants. Microscopic fungae are helpful in the operation of a trickling filter.

Imhoff tank is a two-story tank for clarification of sewage, consisting of an upper sedimentation chamber with a sloping floor leading to slots through which solids settle to a lower digestion chamber.

Incidental waste water reclamation refers to unplanned use of treated effluent after disposal.

Incineration is the burning of digested sludge to remove water and reduce the remaining residue to a safe, noncombustible ash. The ash can then be safely disposed of generally on land or underground.

Indirect reuse is the use of treated water after it has been discharged to a body of natural water.

Industrial wastes are liquid or solid waste substances, not sewage, from any producing, manufacturing, or processing operation.

Interceptor sewers are used in separate sewerage systems to collect the flows from main and trunk sewers and carry them to the point of treatment. In a combined system they also may restrict or limit the flow of waste water to the treatment plant. In case of a sudden surge of water into the sewers, some of the waste water may be diverted directly into a receiving stream, thus protecting the treatment plant from overload.

Ions are electrically charged atoms, or groups of atoms.

Lateral sewers are the pipes that run beneath the surface and collect the wastes from individual homes, industries or institutions.

Mechanical aeration uses mechanical energy to inject air into water, causing wastes to absorb oxygen from the atmosphere.

Oxidation is the breakdown of organic wastes or chemicals in waste water by bacterial or chemical processes in the presence of oxygen.

Oxidation ponds are man-made bodies of water in which wastes are consumed by bacteria as well as by oxygen from the atmosphere, generally with the aid of algae.

Planned Reclaimed Water Use is the deliberate direct or indirect use of treated waste water.

Pollution means an alteration of the quality of the waters of the State by wastes to a degree which unreasonably affects: (1) such waters for beneficial uses or (2) facilities which serve such beneficial uses. Pollution may include contamination. (California Water Code, Section 13050 (1).)

Polyelectrolytes are synthetic chemicals used to speed the removal of solids from waste water. The chemicals cause the solids to flocculate (clump together) rapidly.

Polymer is a chemical compound or mixture of compounds used as a polyelectrolyte.

Primary treatment involves physical processes for removal of settleable solids and floating matter by screening, skimming, and sedimentation.

Reclaimed water is water that, as a result of treatment of wastes, is suitable for a direct beneficial use or a controlled use that would not otherwise occur. (California Water Code, Section 13050 (n).)

Recycling is the direct reuse of water, without treatment, at the same general location or for the same purpose.

Reuse means the additional use of once-used water.

Salts are the minerals which water picks up as it passes through the air, over and underground, and through municipal, industrial, agricultural and other uses.

Sand filters remove suspended solids from waste water as it filters through the sand to produce clarified water which drains from the sand bed. Bacteria may develop in some types of sand filters and aid in the clarification process.

Secondary treatment is the biological process of reducing suspended, colloidal, and dissolved organic matter, from the effluent from primary treatment systems. Secondary treatment is usually carried out through the use of trickling filters or by the activated sludge process.

Sedimentation tanks are used to remove a portion of the solids from waste water where the solids settle to the bottom or float on top. The floatables are skimmed off the top, while the solids on the bottom are collected and pumped to digestion tanks, following which they may be processed by filtration, and sometimes incineration, before final disposal.

Sewage includes all substances, liquid, or solid, associated with human activities, domestic, commercial, and industrial. For this report, the term sewage applies to waterborne wastes collected and treated by communities.

Sludge is the semi-solid matter that settles to the bottom of sedimentation tanks or clarifiers. It is sufficiently liquid in character to be pumped.

Sterilization is the destruction of all living organisms, as contrasted with disinfection, which is the destruction of most disease causing (i.e., infectious) organisms.

Suspended solids are small particles of solid pollutants that are present in waste waters and may be separated by sedimentation aided by chemical and biological treatment and sometimes filtration.

Tertiary treatment is additional treatment to improve the quality of the effluent from secondary treatment systems.

Trickling filter, usually a bed of stones, is a support medium for bacterial growth. Waste water is trickled over the bed so that the bacteria can break down and assimilate the organic wastes.

Virus is the smallest known form of microorganism capable of causing disease.

Waste water is the used water, liquid waste, and drainage of a community, industry, or institution.

Waste water reclamation is the process of treating waste water to produce water for beneficial uses, its transportation to the place of use and its actual use.

CALIFORNIA WATER RECLAMATION LAW

DIVISION 7, CHAPTER 7
SECTIONS 13500–13530
CALIFORNIA WATER CODE

Chapter 7. Water Reclamation

Article 1. Short Title

13500. This chapter shall be known as and may be cited as the Water Reclamation Law.

Article 2. Declaration of Policy

13510. It is hereby declared that the people of the state have a primary interest in the development of facilities to reclaim water containing waste to supplement existing surface and underground water supplies and to assist in meeting the future water requirements of the state.

13511. The Legislature finds and declares that a substantial portion of the future water requirements of this state may be economically met by beneficial use of reclaimed water.

The Legislature further finds and declares that the utilization of reclaimed water by local communities for domestic, agricultural, industrial, recreational, and fish and wildlife purposes will contribute to the peace, health, safety and welfare of the people of the state. Use of reclaimed water constitutes the development of "new basic water supplies" as that term is used in Chapter 5 (commencing with Section 12880) of Part 6 of Division 6.

13512. It is the intention of the Legislature that the state undertake all possible steps to encourage development of water reclamation facilities so that reclaimed water may be made available to help meet the growing water requirements of the state.

Article 3. State Assistance

13515. In order to implement the policy declarations of this chapter, the state board is authorized to provide loans for the development of water reclamation facilities, or for studies and investigations in connection with water reclamation, pursuant to the provisions of Chapter 6 (commencing with Section 13400) of this division.

Article 4. Regulation of Reclamation

13520. As used in this article "reclamation criteria" are the levels of constituents of reclaimed water, and means for assurance of reliability under the design concept which will result in reclaimed water safe from the standpoint of public health, for the uses to be made.

13521. The State Department of Public Health shall establish statewide reclamation criteria for each varying type of use of reclaimed water where such use involves the protection of public health.

13522. Whenever the State Department of Public Health or any local health officer finds that a contamination exists as a result of use of reclaimed water, the department or local health officer shall order the contamination abated in accordance with the procedure provided for in Chapter 6 (commencing with Section 5400) of Part 3, Division 5 of the Health and Safety Code.

13523. Each regional board, after consulting with and receiving the recommendations of the State Department of Public Health, and if it determines such action to be necessary to protect the public health, safety, or welfare, shall establish water reclamation requirements for water which is used or will be used as reclaimed water. Such requirements shall include, or be in conformance with, the statewide reclamation criteria established pursuant to this article. The regional board may require the submission of a preconstruction report for the purpose of determining compliance with the reclamation criteria.

13524. Upon refusal or failure of any person or persons to comply with any water reclamation requirements established by a regional board pursuant to this article, the regional board establishing the requirements may certify the facts to the Attorney General who shall petition the superior court for the county in which the violation or threatened violation occurs for the issuance of a mandatory injunction requiring such person or persons to comply with such water reclamation requirements, and proceedings thereon shall be conducted in the same manner as in any other action brought for an injunction pursuant to Chapter 3 (commencing with Section 525), Title 7, Part 2 of the Code of Civil Procedure.

13525. No person shall use reclaimed water for any purpose for which reclamation criteria have been established until water reclamation requirements have been established therefor pursuant to this article. The Attorney General, at the request of a regional board, shall petition the superior court of the county in which the violation occurs for an injunction pursuant to Chapter 3 (commencing with Section 525) of Title 7 of Part 2 of the Code of Civil Procedure, to enjoin any act, actual or threatened, in violation of this section.

13526. Any person who, after such action has been called to his attention in writing by the regional board, uses reclaimed water for any purpose for which reclamation criteria have been established prior to the establishment of water reclamation requirements, is guilty of a misdemeanor.

13527. In administering any statewide program of financial assistance for water pollution or water quality control which may be delegated to it pursuant to Chapter 6 (commencing with Section 13400) of this division, the state board shall give added consideration to water quality control facilities providing optimum water reclamation and use of reclaimed water.

Nothing in this chapter prevents the appropriate regional board from establishing waste discharge requirements if a discharge is involved.

13528. No provision of this chapter shall be construed as affecting the existing powers of the State Department of Public Health.

Article 5. Surveys and Investigations

13530. The department, either independently or in cooperation with any person or any county, state, federal, or other agency, or on request of the state board, to the extent funds are allocated therefor, shall conduct surveys and investigations relating to the reclamation of water from waste pursuant to Section 230.

NOTE: See Statutory Record for history of any particular provision prior to enactment of Stats. 1969, Ch. 432.

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